

BOLTON SARAH KNOWLES

FAMOUS MEN OF
SCIENCE

Sarah Bolton

Famous Men of Science

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Famous Men of Science

To Those

WHO HAVE EXPRESSED PLEASURE IN MY WORK

I dedicate this book

PREFACE

Garfield said, "No page of human history is so instructive and significant as the record of those early influences which develop the character and direct the lives of eminent men."

These sketches show how young men have overcome difficulties, sometimes poverty, sometimes illness; how they have made failures before finding their true vocation. They show the results of energy, perseverance, and untiring devotion; how a cheerful face and a hopeful spirit like Agassiz's, or a gentle and kindly nature like Darwin's, can win its way against opposition.

A sketch of Benjamin Franklin, which otherwise would have a place in this volume, will be found in "Famous American Statesmen"; also one of Michael Faraday, in "Poor Boys Who Became Famous."

S. K. B.

GALILEO GALILEI

"The same memorable day is marked by the setting of one of the most brilliant stars in the firmament of art and the rising of another in the sphere of science, which was to enlighten the world with beams of equal splendor. On the 18th of February, 1564, Michael Angelo Buonarrotti closed his eyes at Rome, and Galileo Galilei first saw the light at Pisa."

Thus writes young Karl von Gebler, in the best life of Galileo ever written, his dying contribution to literature. Some other authorities place Galileo's birth on February 15.

He was the oldest in a family of five children born to Vincenzo Galilei, a Florentine noble, and Giulia Ammanati, who also belonged to an ancient family. Vincenzo wrote learnedly about music, and taught his boy to play on the lute and the organ; but he was poor and life was a struggle. However beneficial poverty may be in the development of character, most of us do not crave it for our children, so Vincenzo decided to place his son where he could earn a comfortable support. Music did not bring money. Galileo therefore should become a dealer in cloth; a necessity of life, rather than a luxury.

But the boy soon showed great skill in music, surpassing his father. He excelled in drawing and color, and could have become a noted artist. He loved poetry, and had a decided taste for mechanics, making machines of great ingenuity. It soon became evident that such a lad would not be satisfied to spend his life trading in wool.

He must be educated, but how? The family had moved from Pisa, where there were schools of repute, to Florence. An effort had to be made, by the greatest economy, to prepare Galileo to go back to the Pisan University. He showed great aptitude for Latin and Greek, and at seventeen was ready for Pisa.

For what profession should he study? Not what best suited his tastes, but that in which his father thought he could make money, medicine. Poor Vincenzo! who can blame him that he hated poverty for his brilliant son?

At college, Galileo became an ardent student of philosophy, and because he dared to think for himself, and did not always agree with the teachings of Aristotle, he was called "the wrangler." Until he was twenty he was scarcely acquainted with the rudiments of mathematics, because his father thought this study was a waste of time for a man who was to become a physician. How many parents make the mistake of bending their children to their own plans, instead of ascertaining what a boy or girl can do best in the world, and then fitting him or her for it!

While Galileo was studying medicine in Pisa, boarding with a relative, the court of Tuscany came to the city for a few months. Among the suite was Ostilio Ricci, a distinguished mathematician, and Governor of the Pages of the Grand Ducal Court. He was a friend of the Galilei family, and was pleased to see the bright young son, Galileo. When he taught Euclid, the medical student would stand shyly at the schoolroom door, and listen with intense interest. Soon he began to study mathematics secretly; then begged Ricci to teach him, who gladly consented, till the father forbade it, seeing that Euclid interfered with medicine.

Meantime, the youth of nineteen, kneeling at prayers in the Pisa Cathedral, had dreamily watched a bronze lamp swinging from an arch. The oscillations were at first considerable, but as they grew less and less, Galileo observed that they were all performed in the same time, measuring the time by feeling his pulse. The idea occurred to him that an instrument could be constructed which should mark the rate and variation of the pulse. He began to experiment, and soon invented the pulselogia, which the physicians hailed with great delight. The pendulum was not applied to clocks till a half-century later, but its invention attracted the attention of all scholars.

After four years' residence at Pisa, Vincenzo Galilei appealed to the reigning Grand Duke, Ferdinand de Medici, to grant to his son one of the forty free places founded for poor students, but the request was denied, and Galileo, unable to pay for his doctor's degree, was obliged to leave the

university without it. Already he had learned bitter lessons of privation and disappointment, but youth has a brave heart, and looks ever toward the sunlight.

He went back to his home in Florence to study the works of Archimedes, whom he called his "master," to write his first essay on his Hydrostatic Balance, and to earn the reputation of a bold inquirer in geometrical and mechanical speculations. The father had now given up all hope of a fortune coming through medicine! Henceforward, the genius which was to shed lustre on his own name, otherwise buried in obscurity, was to have its own bent, and work out its own destiny.

If we are in earnest, a door opens sooner or later; but our own hands usually open it. At twenty-four a door opened to Galileo. Marquis Guidubaldo, a celebrated mathematician, appreciating what the young scientist had done, began a correspondence with him, and a valuable friendship resulted. The marquis asked him to study the position of the centre of gravity in solid bodies. Galileo applied himself to it, and wrote a valuable essay, which waited fifty years for publication. Perhaps no person can be really great who has not learned patience, and Galileo had many lessons in this virtue before he died.

Through the influence of the marquis, he was brought to the notice of Ferdinand I., reigning Grand Duke, who appointed him to the mathematical professorship at Pisa. This was a great honor for a young man of twenty-six, one who had been too poor to take his degree. The salary was small, less than a hundred dollars a year; but he earned somewhat by the practice of medicine, by lectures on Dante and other literary subjects, and by lessons to private pupils. Of course, he had little or no leisure; but he thus learned one of the most valuable lessons of life, – to treasure time as though it were gold. How glad his father and mother must have been that their wool projects had come to naught!

The professors at Pisa, with a single exception, Jacopo Mazzoni, in the chair of philosophy, were opposed to the new-comer. They were all disciples of Aristotle, and had not Galileo, when a boy among them, dared to oppose the great Grecian? And now, to make matters worse, he had taken some friends to the top of the Leaning Tower, and had put to the test the belief of two thousand years, – that the rate at which a body falls depends upon its weight. When the different weights fell to the pavement at the foot of the Leaning Tower, at the same time, the learned were astonished. If Aristotle could be wrong in one thing, he might in others, and this young man would revolutionize the teaching of the times!

The feeling became so strong against the investigator that after three years at Pisa he resigned. When will the world learn toleration for those whose opinions are different from the popular thought? From Galileo to Darwin we have persecuted the men and women whose views were unlike our own in theology, in science, or in social matters.

Through his friend, the Marquis Guidubaldo, the mathematical professorship at Padua was obtained for Galileo. He was now twenty-nine, and becoming widely known throughout Italy. His father had just died, leaving the whole family, a wife and four children, dependent upon him for support; not a small matter for an ambitious and hard-working professor.

Padua gave the young man cordial welcome. Vincenzo Pinelli, a learned nobleman, who possessed eighty thousand volumes, mentioned him to Tycho Brahe, the great Danish astronomer, as a man whom it would be well to cultivate; but the Dane was too cautious about his own reputation, and did not write Galileo till eight years later, and died the following year.

An associate of Tycho Brahe was wiser than his master, and sent Galileo his new book, "Prodromus Dissertationum Cosmographicum." A warm letter of thanks went back to the immortal John Kepler, saying: "Many years ago I became a convert to the opinions of Copernicus, and by that theory have succeeded in fully explaining many phenomena which on the contrary hypothesis are altogether inexplicable. I have drawn up many arguments and compilations of the opposite opinions, which, however, I have not hitherto dared to publish, fearful of meeting the same fate as our master Copernicus, who, although he has earned for himself immortal fame amongst the few, yet amongst the greater number appears as only worthy of hooting and derision; so great is the number of fools."

John Kepler, like Galileo, lived a pathetic life. His childhood was spent in the little beer-shop of his wretchedly poor father. At six he had a severe attack of small-pox, and his eyes were permanently weakened. He was put to the plough, but his delicate body could not bear the work. At last, through charity, he became a theological student at Tübingen. But here he began to think for himself, and, probably, would have been obliged to leave the university.

Fortunately for science, he heard some lectures given by Michael Möstlen, famous in mathematics and astronomy. A new world opened to Kepler. He applied himself with all the ardor of youth, and at twenty-two became professor of mathematics at Grätz, in Styria. He was soon driven away from this Catholic stronghold, on account of his Protestant faith. Tycho Brahe heard of his needs, and made him his assistant at Prague, with a salary of seven hundred and fifty dollars a year. This seemed regal splendor to the poor astronomer. Now he studied the heavens with hope and delight.

But sorrows soon came. His children died, his wife became insane, and died also. The salary could not be paid, on account of the religious wars which convulsed Germany. He wrote almanacs, took private pupils, and in all ways tried to support his second wife and children, while he studied the heavens year by year, discovering his three great laws. The mathematical calculations for the first law, that the planets move in elliptical orbits round the sun, which is placed at one of the foci, filled seven hundred pages. His "Harmonies of the World" contained his third great law: "The squares of the periodic times of the planets are proportioned to the cubes of their mean distances from the sun."

Such was his joy when he discovered this law, after seventeen years of labor, that he said, "I have written my book. It will be read; whether in the present age or by posterity matters little. It can wait for its readers. Has not God waited six thousand years for one to contemplate his works?" In a last fruitless attempt to recover twenty-nine thousand florins, owed him by the government, worn out with want and disappointment, he fell ill and died at Ratisbon, leaving thirty-three works, twenty-two volumes in manuscript, and his family in the direst poverty. Such was the man who admired Galileo in his youth, and who stands with him in the admiration of the generations that have come and gone since these two men lived and wrote and suffered.

At Padua, Galileo soon attracted great numbers to his class-room. Often a thousand gathered to hear his lectures, and when the hall was too cramped, he spoke to the people in the open air. He was above the middle height, well proportioned, with cheerful countenance, witty in conversation, and enthusiastic in his manner. So learned that he could repeat by heart much of the works of Virgil, Ovid, Horace, and Seneca; he was yet modest and unassuming, saying that he never met a man so ignorant but that something might be learned from him.

He labored incessantly. He wrote treatises on Fortifications, on Mechanics, on Gnomonics, on the laws of motion, on the celestial globe, which were copied by his pupils, and sent by them far and wide over Europe. He took a workman into his family, and began to superintend the making of the compass which he had invented, and the thermoscope, or heat indicator, which led in later years to the thermometer. His experiment was made by a "glass bottle about the size of a hen's egg, the neck of which was two palms long, and as narrow as a straw. Having well heated the bulb in his hands, he placed its mouth in a vessel containing a little water, and withdrawing the heat of his hand from the bulb, instantly the water rose in the neck, more than a palm above the level of the water in the vessel."

During the first six years at Padua, his salary rose from about one hundred dollars to five hundred dollars, yearly. All this time, when his mind should have been free from care for his great work, he was beset with difficulties. His sister, Virginia, had married before his father's death, but a promised dowry had never been paid, and now the brother-in-law demanded the payment. The mother, worried over the prospect, wrote to her son, Galileo, "If you carry into effect your intention of coming here next month, I shall be rejoiced, only you must not come unprovided with funds, for I see that Benedetto is determined to have his own, that is to say, what you promised him; and he threatens loudly that he will have you arrested the instant you arrive here. And as I hear you bound

yourself to pay, he would have the power to arrest you, and he is just the man to do it. So I warn you, for it would grieve me much if anything of the kind were to happen."

Livia, another sister, had become engaged to a Pisan gentleman, with the promise of a dowry of eighteen hundred ducats, eight hundred of which must be paid down. The "Pisan gentleman" could not burden himself with a wife, without funds to help support her and himself. So Galileo generously, if not wisely, borrowed six hundred ducats, and paid the necessary eight hundred, giving his sister beautiful clothes and house furnishings.

Besides these sisters, Galileo had a lazy brother to provide for, Michelangelo, a young man of some musical talent and elegant manners, with the not unusual gift of being able to spend much and earn little. Galileo obtained a situation for him with a Polish prince, and spent two hundred crowns in getting him ready for the new position. He went thither, but soon returned, and another place had to be procured for him, at the court of the Duke of Bavaria.

While there, instead of helping to pay his sister's dowry, as he had promised, he married; had an extravagant wedding feast, and then wrote his hard-working brother: "I know that you will say that I should have waited, and thought of our sisters before taking a wife. But, good heavens! the idea of toiling all one's life just to put by a few farthings to give one's sisters! This yoke would be indeed too heavy and bitter; for I am more than certain that in thirty years I should not have saved enough to cover this debt."

With all the pressure upon him for money, Galileo kept steadily on in his absorbing studies. In the year 1609, he constructed a telescope. It is true that Hans Lipperhey, of Germany, had invented a spy-glass, and presented it to Prince Maurice, so that the principle was understood; but nobody gave it practical illustration till Galileo, having heard of the glass, began to reflect how an instrument could be made to bring distant objects near. In a leaden tube, he fixed two glasses, both having one side flat, and the other side of the one concave, and the other convex. By this, objects appeared three times nearer and nine times larger. A few days later, he hastened with his leaden tube to Venice, to exhibit it to the Doge and the Senate. He wrote to a friend: —

"Many gentlemen and senators, even the oldest, have ascended at various times the highest bell-towers in Venice, to spy out ships at sea, making sail for the mouth of the harbor, and have seen them clearly, though without my telescope they would have been invisible for more than two hours. The effect of this instrument is to show an object at a distance of, say, fifty miles, as if it were but five miles off.

"Perceiving of what great utility such an instrument would prove in naval and military operations, and seeing that His Serenity greatly desired to possess it, I resolved four days ago to go to the palace and present it to the Doge as a free gift. And on quitting the presence-chamber, I was commanded to bide awhile in the hall of the senate, whereunto, after a little, the Illustrissimo Prioli, who is Procurator and one of the Riformatori of the University, came forth to me from the presence-chamber, and, taking me by the hand, said, 'that the senate, knowing the manner in which I had served it for seventeen years at Padua, and being sensible of my courtesy in making it a present of my telescope, had immediately ordered the Illustrious Riformatori to elect me (with my good-will) to the professorship for life, with a stipend of one thousand florins yearly.'"

This must have been a comfort to the now famous Galileo, as it was, doubtless, to the useless Michelangelo, and the two brothers-in-law! He could now live in comparative peace and rest.

On his return to Padua, he began eagerly to study the heavens. He found that the surface of the moon was mountainous; that the Milky Way was composed of an immense number of small stars and nebulous matter; that Orion, instead of being made up of seven heavenly bodies, had over five hundred stars; and that the Pleiades were not seven, but thirty-six. In January, 1610, he discovered the four moons of Jupiter, and that they revolved around him. July 25 of the same year, he discovered the ring of Saturn; in October, the phases of Venus, and later, the solar spots.

Florence and Padua were in a blaze of excitement. These new discoveries seemed to prove that the earth was not the centre of the universe, but that Copernicus was right when he declared the sun to be the centre. Great opposition began to develop itself. Some of the Aristotelians declared that the telescope of Galileo showed things which do not exist. "It was ridiculous," they said, "that four planets (Jupiter's moons) were chasing each other around a large planet.

"It is angels who make Saturn, Jupiter, the sun, etc., turn round. If the earth revolves, it must also have an angel in the centre to set it in motion; but if only devils live there, it would, therefore, be a devil who would impart motion to the earth.

"The planets, the sun, the fixed stars, all belong to one species; namely, that of stars – they, therefore, all move, or all stand still.

"It seems, therefore, to be a grievous wrong to place the earth, which is a sink of impurity, among the heavenly bodies, which are pure and divine things."

Libri, one of the Pisan professors, spoke of the new discoveries as "celestial trifles." When he died, Galileo naïvely remarked, "Libri did not choose to see my celestial trifles while he was on earth; perhaps he will, now he is gone to heaven."

Galileo now longed for freedom from teaching, that he might have his time for study and writing. He had planned, he said, "two books on the system of the universe; an immense work (*idea, concetto*), full of philosophy, astronomy, and geometry: three books on local motion, a science entirely new; no one, either ancient or modern, having discovered any of the marvellous accidents which I demonstrate in natural and violent motions; so that I may, with very great reason, call it a new science, discovered by me from its very first principles: three books on mechanics, two on the demonstration of its first principles, and one of problems; and though this is a subject which has already been treated by various writers, yet all which has been written hitherto neither in quantity nor otherwise is the quarter of what I am writing on it. I have also various treatises on natural subjects, on sound and speech, on sight and colors, on the tide, on the composition of continuous quantity, on the motion of animals, and others; besides, I have also an idea of writing some books on the military art, giving not only a model of a soldier, but teaching, with very exact rules, all which it is his duty to know that depends on mathematics; as, for instance, the knowledge of encampment, drawing up battalions, fortifications, assaults, planning, surveying, the knowledge of artillery, the use of various instruments, etc."

With all this work in mind, he resigned the professorship at Padua, and removed to Florence, the Grand Duke Cosmo II. giving him a yearly salary of about one thousand dollars, and the title of Philosopher to His Highness.

His first thought, as ever, was for his family. He asked an advance of two years' salary, and paid the dowry debts of his sisters' grasping husbands.

In 1611, his expenses paid by the Grand Duke, he went to Rome to show his "celestial novelties," as they were called, to the pope and the cardinals. He was received with great attention, and all seemed delighted to look upon the wonders of the heavens, provided always that nothing could be proved against the supposed assertion of the Bible that the earth did not move!

Galileo soon published his "Discourse on Floating Bodies," which aroused violent opposition; "Spots observed on the Body of the Sun," and the "Discourse on the Tides."

Four years later, he was again in Rome to plead for the Copernican system, and to defend his own conduct in advocating a thing in opposition to the Catholic church. He said: "I am inclined to think that the authority of Holy Scripture is intended to convince men of those truths which are necessary for their salvation, and which, being far above man's understanding, cannot be made credible by any learning, or any other means than revelation by the Holy Spirit. But that the same God, who has endowed us with senses, reason, and understanding, does not permit us to use them, and desires to acquaint us in any other way with such knowledge as we are in a position to acquire for ourselves by means of those faculties, *that*, it seems to me, I am not bound to believe, especially concerning those sciences about which the Holy Scriptures contain only small fragments and varying

conclusions; and this is precisely the case with astronomy, of which there is so little that the planets are not even all enumerated."

However, in spite of Galileo's logic, the church decreed that all books which stated the Copernican system as true should be prohibited; as a mathematical hypothesis, it might be speculated upon. This was a great disappointment to Galileo, who loved and revered the Roman Catholic faith. He went home to the Villa Segni, at Bellosguardo, near Florence, and for seven years led a studious and secluded life.

His greatest comfort, during these quiet years, was the devotion of his daughter, Polissena, who had entered a convent as Sister Maria Celeste. While in Padua, Galileo had three children by Marina Gamba, a Venetian woman of inferior station. She afterwards married a man of her own class, and Galileo took his children to his own home; a condition of things possible with the low moral standard of the time. The two daughters were placed in a convent, while the son, Vincenzo, was educated for the profession of medicine, but he seems to have been a disappointment and a source of discomfort.

Maria Celeste, in the convent of St. Matthew, loving and tender, and helpful to all around her, wrote constantly to the man whom she idolized. "I put by carefully," she says, "the letters you write me daily, and when not engaged with my duties, I read them over and over again. This is the greatest pleasure I have, and you may think how glad I am to read the letters you receive from persons who, besides being excellent in themselves, have you in esteem."

Again she writes, "I leave you to imagine how pleased I am to read the letters you constantly send me. Only to see how your love for me prompts you to let me know fully what favors you receive from these gentlemen is enough to fill me with joy. Nevertheless I feel it a little hard to hear that you intend leaving home so soon, because I shall have to do without you, and for a long time too, if I am not mistaken. And your lordship may believe that I am speaking the truth when I say that except you there is not a creature who gives me any comfort. But I will not grieve at your departure because of this, for that would be to complain when you had cause for rejoicing. Therefore I too will rejoice, and continue to pray God to give you grace and health to make a prosperous journey, so that you may return satisfied, and live long and happily, all which, I trust, will come to pass by God's help.

"I send two baked pears for these days of vigil. But as the greatest treat of all, I send you a rose, which ought to please you extremely, seeing what a rarity it is at this season. And with the rose, you must accept its thorns, which represent the bitter passion of our Lord, while the green leaves represent the hope we may entertain that through the same Sacred Passion we, having passed through the darkness of this short winter of our mortal life, may attain to the brightness and felicity of an eternal spring in heaven."

"Only in one respect does cloister life weigh heavily on me; that is, that it prevents my attending on you personally, which would be my desire, were it permitted. My thoughts are always with you."

And so the seven years of study went by, with the sweet love of Maria Celeste to brighten them. There are none so great that they can live without affection.

At the end of the seven years, Urban VIII. came to the pontifical throne, and Galileo and other scientists rejoiced, for he had seemed liberal in thought and generous in heart. When he was cardinal, he had sent a letter to Galileo, saying, "The esteem which I always entertain for yourself and your great merits has given occasion to the enclosed verses. If not worthy of you, they will serve at any rate as a proof of my affection, while I purpose to add lustre to my poetry by your renowned name. Without wasting words, then, in further apologies, which I leave to the confidence which I place in you, I beg you to receive with favor this insignificant proof of my great affection."

At Easter, 1624, Galileo, now sixty years old, resolved to proceed to Rome, to welcome the new pope, and urge his approval of the Copernican theory. Frail in health, he was carried most of the way in a litter. During a visit of six weeks, he had six long audiences with Urban VIII.; but, though he was affably received, the pope was in no wise convinced, but rather tried to convince Galileo that he was in error.

Yet so kind was he that Galileo went back to Florence with the hope and belief that he could bring out his great work, "Dialogues on the Two Principal Systems of the World, the Ptolemaic and Copernican," without opposition from the church. In this book, Galileo gave the results of scientific research and discovery in the half century preceding, using such clear yet brilliant style in writing as to make the work attractive even to the unlearned.

It was ready for publication in March, 1630, but to be sure that the pope did not object, Galileo was urged to go in person to Rome. He went and presented the matter to Urban, who gave his consent provided that the title should show that the Copernican system was treated as a hypothesis merely, and that he, the pope, should write the closing argument.

Rather than forego the publication of that upon which he had worked for years, Galileo consented, and returned to Florence. A license to publish was then obtained from the Inquisitor-General, and the Vicar-General of Florence, after great delay. A second and a third time the papal authorities wished to look over the manuscript. Two years went slowly by.

Other anxieties came to the man of sixty-eight, besides the long delay. The impecunious Michelangelo sent his wife, seven children, and a German nurse, to the home of Galileo, to be taken care of. The eldest nephew was sent to Rome to study music. He was found to be obstinate, impudent, and dissolute, "wicked ways" which his weak and indulgent father said "he did not learn from me, or any one else belonging to him. It must have been the fault of his wet nurse!"

Galileo's son Vincenzo had married and brought his wife home to live. Strange fortune for this man of genius! Strange that he must have helpless relatives, and constant pecuniary troubles. Most great lives are as pathetic as they are great.

As ever, the one gleam of light was the daily letter from Maria Celeste, in which she expressed a tenderness beyond what any daughter ever had for a father. "But I do not know how to express myself, except by saying that I love you better than myself. For, after God, I belong to you; and your kindnesses are so numberless that I feel I could put my life in peril, were it to save you from any trouble, excepting only that I would not offend His Divine Majesty."

Finally Galileo moved to Arcetri, over against the convent, to be near the one who alone satisfied his heart.

In January, 1632, the "Dialogues" appeared. Copies were sent to his friends and disciples throughout Italy. The whole country applauded, and at last Galileo seemed to have won the homage he had so long deserved.

But a storm was gathering. Enemies were at work prejudicing the mind of Urban VIII., making him feel that Galileo had wrought evil to the church. At once an order came from the Inquisition to secure every copy in the booksellers' shops throughout Italy, and to forward all copies to Rome.

In October of the same year of publication, Galileo was summoned to appear at Rome, to answer to that terror of past centuries, the charge of heresy. His friends urged that he was old and feeble, and that he would die on the journey, but Urban's commands were peremptory.

Galileo was deeply depressed by the summons, and wrote a friend: "This vexes me so much that it makes me curse the time devoted to these studies, in which I strove and hoped to deviate somewhat from the beaten track generally pursued by learned men. I not only repent having given the world a portion of my writings, but feel inclined to suppress those still in hand, and to give them to the flames, and thus satisfy the longing desire of my enemies, to whom my ideas are so inconvenient."

On January 20, 1633, the decrepit old man set out in a litter for Rome, arriving on February 13. On April 12, he was brought before the Inquisition, and briefly examined and then remanded to prison, though treated with great leniency. The anxiety and deprivation from outdoor exercise brought on illness, and he was confined to his bed till led a second time before the Inquisition, April 30.

Weak, aged, in fear of torture, he made the melancholy confession that his "error had been one of vainglorious ambition, and pure ignorance and inadvertence." Pure ignorance! from the man who had studied for fifty years all that the world knew of science! But he recalled how men had died at

the stake for offending the church. The world is not full of men and women who can suffer death for their convictions, however much we may admire such courage. On May 10, he was summoned a third time before the Inquisition, and told that he had eight days in which to write his defence. In touching language he stated how the book had been examined and re examined by the authorities, so that there might be nothing heterodox in it; and then he urged them to consider his age and feeble health.

A fourth time he came before the Holy Congregation, June 21, and was asked whether he held that the sun is the centre of the solar system, and that the earth is not the centre, and that it moves. He replied, "I do not hold, and have not held this opinion of Copernicus since the command was intimated to me that I must abandon it; for the rest, I am here in your hands, – do with me what you please."

And then June 22, in the forenoon, in the large hall of the Dominican Convent of St. Maria sopra la Minerva, in the presence of cardinals and prelates, he heard his sentence.

"The proposition that the sun is the centre of the world and does not move from its place is absurd, and false philosophically, and formally heretical, because it is expressly contrary to the Holy Scripture.

"The proposition that the earth is not the centre of the world and immovable, but that it moves, and also with a diurnal motion, is equally absurd and false philosophically; and theologically considered, at least, erroneous in faith... Invoking, therefore, the most holy name of our Lord Jesus Christ and of His most glorious mother and ever Virgin Mary ... we say, pronounce, sentence, declare, that you, the said Galileo, by reason of the matters adduced in process, and by you confessed as above, have rendered yourself, in the judgment of this Holy Office, vehemently suspected of heresy, – namely, of having believed and held the doctrine, which is false and contrary to the sacred and divine Scriptures, – that the sun is the centre of the world and does not move from east to west, and that the earth moves and is not the centre of the world... We condemn you to the formal prison of this Holy Office during our pleasure, and, by way of salutary penance, we enjoin that for three years to come you repeat once a week the seven Penitential Psalms."

Galileo was also required to "abjure, curse, and detest the aforesaid errors and heresies." And then the white-haired man of seventy, humbly kneeling before the whole assembly, made the pitiful abjuration of his belief. "I abjure with a sincere heart and unfeigned faith, I curse and detest the said errors and heresies, and, generally, all and every error and sect contrary to the Holy Catholic Church."

Pitiful spectacle of intolerance! If we of this nineteenth century have learned to tolerate and treat with respect the beliefs of others though widely divergent from our own, perhaps this wretched drama was not acted in vain.

It has been said that Galileo exclaimed as he rose from his feet, "*E pur si muove*," "It moves, for all that," but this would have been well nigh an impossibility, in the midst of men who would instantly have taken him to a dungeon, and the story is no longer believed.

On July 9, poor Galileo was allowed to leave Rome for Siena, where he stayed five months in the house of the archbishop, and then became a prisoner in his own house at Arcetri, with strict injunctions that he was "not to entertain friends, nor to allow the assemblage of many at a time."

He wrote sadly to Maria Celeste, "My name is erased from the book of the living." Tender words came back, saying that it seemed "a thousand years" since she had seen him, and that she would recite the seven penitential psalms for him, "to save you the trouble of remembering it."

In less than a year, sweet Maria Celeste had said the last psalms for him. She died April 1, 1634, at thirty-three years of age, leaving Galileo heart-broken; "a woman," he said, "of exquisite mind, singular goodness, and most tenderly attached to me."

He went to work on another book, but he said, pathetically, "I hear her constantly calling me!" Beautiful spirit, that will forever shed a halo around the name of Galileo Galilei!

In the summer of 1636, he completed his "Dialogues on Motion," and sent it to Leyden for publication. The next year he made his last discovery, known as the moon's librations.

The house at Arcetri had become dark and lonely. The wife of Michelangelo, her three daughters and a son, had all died of the plague. It was doubly dark, for Galileo had become hopelessly blind, "so that this heaven, this earth, this universe, which I by my marvellous discoveries and clear demonstrations had enlarged a hundred thousand times beyond the belief of the wise men of bygone ages, henceforward for me is shrunk into such a small space as is filled by my own bodily sensations."

His last work was a short treatise on the secondary light of the moon. "I am obliged now," he said, sadly, "to have recourse to other hands and other pens than mine since my sad loss of sight. This, of course, occasions great loss of time, particularly now that my memory is impaired by advanced age; so that in placing my thoughts on paper, many and many a time I am forced to have the foregoing sentences read to me before I can tell what ought to follow; else I should repeat the same thing over and over."

He had planned other work, but death came on the evening of January 8, 1642, eight years after Celeste left him. His beloved pupils, Torricelli and Viviani, and his son Vincenzo, stood by his bedside.

He desired to be buried in the family vault of the Galilei in Santa Croce, at Florence, and the city at once voted a public funeral and three thousand crowns for a marble mausoleum. But the church at Rome prevented, lest the pernicious doctrine that the earth moves, should thereby have confirmation. He was therefore buried in an obscure corner of Del Noviziato, a side chapel of Santa Croce.

A century later, March 12, 1737, in the presence of the learned men of Italy, with great ceremony, the bones of Galileo were removed to a new resting-place in Santa Croce, and buried with his beloved friend, Viviani. An imposing monument was erected over him. The truth finally triumphed, as it always does. The works of Galileo, in sixteen volumes, are no longer prohibited, as they were in his lifetime.

SIR ISAAC NEWTON

In the same year, 1642, in which Galileo, sad and blind, went away from the earth, Sir Isaac Newton came to make his home upon it.

He was born December 25, the only child of Isaac Newton and Hannah Ayscough. The father died at thirty-seven, a few months after his marriage, and the young wife, after the birth of her child, was both father and mother to the helpless infant. He was so frail that there seemed little probability that he could live to manhood, or even boyhood. Naturally, between mother and son there grew a most ardent affection, which neither time nor death could change.

The manor-house of Woolsthorpe in Colsterworth, Lincoln county, was a two-story stone building, owned for a century by the Newton family, and bringing a limited income from the little farm in connection with it. Here Isaac passed his childhood, going to the schools near by, and learning to read, write, and cipher.

At twelve, he was sent to the public school at Grantham, where he showed little taste for study, and managed easily to stand at the foot of his class. When he was the last in the lowermost form but one, the boy next above him, as they were going to school, gave Isaac a kick, which occasioned severe pain. Stirred with wrath, Isaac challenged the other boy to a fight. For this purpose, they repaired to a neighboring churchyard, where young Newton, though much the smaller and weaker of the two, pounded his antagonist till he was glad to come to any terms of submission.

He resolved now that this boy should no longer stand above him in scholarship, and with a new ambition and energy born of his insult, he soon rose to the highest place in the school. It was not idleness, probably, that made Newton a poor scholar, but his mind was absorbed with making saws, hammers, hatchets, and other tools.

He made a windmill and placed it on the top of his home, the wind putting it in motion. When there was no wind, a novel expedient was resorted to. A mouse, which was called "the miller," was trained to turn the windmill by walking on a tread wheel, with some corn just beyond his reach! All through life, he was exceedingly kind to animals, and could never tolerate shooting or hunting for sport. He objected to one of his nephews, when praised in his presence, "that he loved killing of birds," and this was sufficient to win his disesteem. It is probable, therefore, that the little mouse was kindly cared for by the young experimenter.

He also made a water clock, about four feet high, with a dial-plate at the top, with figures of the hours. The index was turned by a piece of wood, which either fell or rose by water dropping. Every morning the lad supplied his clock with the proper amount of water.

Besides these, he invented a four-wheeled carriage, which was moved with a handle by the person who sat in it. For his boy friends, he made lanterns of "crimped paper" with a candle inside, to light them to school in the dark winter mornings, and paper kites of the best form and proportion. In dark nights he tied the lanterns to the tails of his kites, and ignorant people sometimes mistook them for comets!

On the manor-house at Woolsthorpe he carved sun-dials, which were visible a century later. He was a "sober, silent, and thinking lad," who was always hammering in his room, or making drawings with his pen and pencil, designing with charcoal on his walls, birds, animals, ships, and mathematical diagrams.

Mrs. Newton, the mother, had married again, after a singular courtship. "Mr. Smith, a neighboring clergyman, who had a very good estate, had lived a bachelor till he was pretty old, and, one of his parishioners advising him to marry, he said he did not know where to meet with a good wife. The man answered, 'The widow Newton is an extraordinary good woman.' 'But,' said Mr. Smith, 'how do I know she will have me, and I don't care to ask and be denied; but if you will go and ask her, I will pay you for your day's work.'"

"He went accordingly. Her answer was, she would be advised by her brother Ayscough, upon which Mr. Smith sent the same person to Mr. Ayscough on the same errand, who, upon consulting with his sister, treated with Mr. Smith, who gave her son Isaac a parcel of land, one of the terms insisted upon by the widow if she married him."

Though for a time she was thus removed from Isaac, leaving him with his grandmother, on the death of Rev. Mr. Smith, she returned to the manor-house.

When Isaac had reached his fifteenth year, his mother, not seeming to think of any profession for her mechanical son, decided to make of him a farmer and grazier. On Saturdays, the market day at Grantham, she would send him with grain and other agricultural produce, in the care of an old and trusty servant. The boy had no taste for selling produce, and would hasten to the attic in the house of Mr. Clark, an apothecary, with whom he had boarded while at school, and there spend his hours in reading old books, till the time came for him to go home, the servant meantime having sold the vegetables.

Sometimes, however, the lad would not go as far as Grantham, but, seating himself beside a hedge along the road, would read some favorite author till the servant returned. When his mother sent him to watch the cattle, they enjoyed a neighbor's corn-field, while he enjoyed a book or whittled out water-wheels. It did not seem intentional disobedience toward a mother of whom he was very fond, but complete absorption in some other pursuit.

When he was sixteen he was greatly interested in finding the proper form of a body which would offer the least resistance when moving in a fluid. In a severe storm, to test the force of the gale, he jumped first in the direction in which the wind blew, and then in opposition to the wind, and after measuring the length of the leap in both directions, and comparing it with the length to which he could jump in a perfectly calm day, he was enabled to compute the force of the storm.

His mother soon found that her boy would not make a successful farmer, and sent him back to school at Grantham, to prepare for Trinity College, Cambridge, which he entered when he was nineteen.

It is probable that the time spent at Grantham was a happy time; for young Newton there met and, it is said, loved Miss Storey, sister of Dr. Storey, a physician near Colsterworth, and daughter of the apothecary's second wife. She was two or three years younger than Newton, a girl of attractive face and unusual talents. As his income as a Fellow was small, after leaving college, they did not marry, though his interest in her continued unabated through life. Though she was twice married, he never paid a visit to Woolsthorpe without going to see her, and liberally relieved her from little pecuniary embarrassments, when his own circumstances had become easy. How the world loves constancy; an affection which knows no change! That he would have been happier in those quiet years of study, even in his poverty, had he married, is probable; but that the world gained by his undivided devotion to science, is equally probable.

On July 8, 1661, Newton entered college, and soon, through the study of Descartes' Geometry, showed his skill in higher mathematics. And now began an almost unexampled development of mind.

At twenty-two, he was studying a comet so closely, and the circles and halo round the moon, that he impaired his health by sitting up late at night. In 1665, May 20, when he was twenty-three, he committed to writing his first discovery of fluxions – "the infinitely small increase or decrease of a variable or flowing quantity in a certain infinitely small and constant period of time."

The same year, when the college had been dismissed on account of the plague in Cambridge, Newton made his immortal discovery of the Attraction of Gravitation. While sitting alone in his garden at Woolsthorpe, and observing an apple fall to the ground, it occurred to him that as the same power by which the apple fell was not sensibly diminished at the summits of the loftiest spires, nor on the tops of the highest mountains, it might extend to the moon, about which he had been studying, and retain her in her orbit. If to the moon, why not to the planets?

The tree from which the apple fell was so much decayed in 1820, that it was cut down, but the wood was carefully preserved by Mr. Turnor of Stoke Rocheford.

In the beginning of the following year, 1666, when Newton was twenty-four, he purchased a prism, in order to make some experiments on Descartes' theory of colors. He made a hole in his window shutter, darkened the room, and admitted a ray of the sunlight. On the opposite wall he saw the solar or prismatic spectrum, an elongated image of the sun, about five times as long as it was broad, and consisting of *seven* different colors; red, orange, yellow, green, blue, indigo, and violet. White light was thus discovered to be of a compound nature; a mixture of all the colors. He said, "Whiteness is the usual color of light; for light is a confused aggregate of rays endued with all sorts of colors, as they are promiscuously darted from the various parts of luminous bodies." If any one color predominates, the light will incline to that color, as the yellow flame of a candle. Heretofore, there had been all sorts of conjectures about the nature and origin of colors. Descartes believed them to be a modification of light, depending on the direct or rotary motion of its particles. But Newton showed by many experiments that color is a property of light, or innate in light itself. We speak of a thing as red because it reflects red, and absorbs all the other colors. The green leaf stops or absorbs the red, blue, and violet rays of the white light, and reflects and transmits only those which compose its green.

He also found that the red rays are refracted or turned out of their course least of all the colors, and violet most, thereby discovering the different refrangibility of the rays of light; "a discovery which has had the most extensive applications to every branch of science, and, what is very rare in the history of inventions, one to which no other person has made the slightest claim."

His beautiful experiments with rings resulted in his Scale of Colors, of great value in optical research.

In 1668, when Newton was twenty-six, he constructed a small reflecting telescope, and soon a larger one, which he sent to the Royal Society; and was made a member of that body, in 1671. Two years previously he had been appointed to the Lucasian professorship of mathematics at Cambridge.

He was now, at twenty-seven, spoken of as a man of "unparalleled genius." He had discovered the compound nature of white light, the attraction of gravity, fluxions, and made the first reflecting telescope ever directed toward the heavens, though one had been invented previously, by James Gregory, of Aberdeen. The boy who had thought of a mouse to turn his windmill had thought out some of the sublimest things in nature, and was henceforward to rank as one of the few masterminds of science. Newton's doctrine of colors met with the most bitter opposition. At last, he became so tired of the controversy, that he wrote Leibnitz, "I was so persecuted with discussions arising out of my theory of light, that I blamed my own imprudence for parting with so substantial a blessing as my quiet to run after a shadow." To another he wrote, "I see I have made myself a slave to philosophy; but if I get free of Mr. Linus's business, I will resolutely bid adieu to it eternally, excepting what I do for my private satisfaction, or leave to come out after me; for I see a man must either resolve to put out nothing new, or to become a slave to defend it."

Newton was also troubled pecuniarily at this time, and asked to be excused from the weekly payments to the Royal Society, thereby resigning his membership. He even meditated the study of law, as his income was so limited. Strange that so many of the great things of this life are wrought out by those who are in sorrow or privation.

But amid all the opposition to his discoveries and his poverty, the unparalleled devotion to study was continued. When he was weary of other branches, he said "he refreshed himself with history and chronology." Years afterward he published the "Chronology of Ancient Kingdoms amended, to which is prefixed a short chronicle, from the first memory of things in Europe, to the Conquest of Persia, by Alexander the Great." Says a gentleman who was with him for years, "I never knew him to take any recreation or pastime, either in riding out to take the air, walking, boating, or any other exercise whatever, thinking all hours lost that were not spent in his studies, to which he kept so close that he seldom left his chamber except at term time, when he read in the schools, as being Lucasianus

Professor, where so few went to hear him, and fewer that understood him, that oftentimes he did in a manner, for want of hearers, read to the walls...

"So intent, so serious upon his studies that he ate very sparingly, nay, oftentimes he has forgot to eat at all, so that, going into his chamber, I have found his mess untouched, of which when I have reminded him he would reply, 'Have I?' and then making to the table, would eat a bit or two standing, for I cannot say I ever saw him sit at table by himself. At some seldom entertainments the masters of colleges were chiefly his guests.

"He very rarely went to bed till two or three of the clock, sometimes not till five or six, lying about four or five hours, especially at spring and fall of the leaf, at which times he used to employ about six weeks in his elaboratory, the fire scarcely going out either night or day, he sitting up one night, and I another, till he had finished his chemical experiments, in the performances of which he was the most accurate, strict, exact..."

When his most intense studies were carried on, "he learned to go to bed at twelve, finding by experience that if he exceeded that hour but a little, it did him more harm in his health than a whole day's study."

"He very rarely went to dine in the hall, except on some public days, and then if he has not been minded, would go very carelessly, with shoes down at heels, stockings untied, surplice on, and his head scarcely combed... At some seldom times when he designed to dine in the hall, he would turn to the left hand and go out into the street, when making a stop when he found his mistake, would hastily turn back, and then sometimes, instead of going into the hall, would return to his chamber again... In his chamber he walked so very much that you might have thought him to be educated at Athens, among the Aristotelian sect."

So absent-minded was he, the story is told of him, that going home to Colsterworth, he led his horse up a hill. When he designed to remount, the animal had slipped the bridle and gone away unperceived, though Newton held the bridle in his hand all the time. He would often sit down on his bedside after he rose, and remain there for hours without dressing, so completely absorbed was he in his thought. How few in all this world have been so devoted to science! And yet how many expect success without this devotion!

The same gentleman writes of Newton, "His carriage was very meek, sedate, and humble, never seemingly angry, of profound thought, his countenance mild, pleasant, and comely. I cannot say I ever saw him laugh but once."

In 1687, when Newton was forty-five, his *Philosophiæ Naturalis Principia Mathematica* was published. "The *Principia* consists of three books. The First Book, besides the definition and axioms, or laws of motion, with which it begins, consists of fourteen sections, in the first of which the author explains the method of prime and ultimate ratios used in his investigations, and which is similar to the method of fluxions. The other sections treat of centripetal forces, and motions in fixed and movable orbits.

"The Second Book consists of nine sections, and treats of bodies moving in resisting media, or oscillating as pendulums.

"The Third Book consists of five sections, on the Causes of the System of the World, on the Quantity of Lunar Errors, on the Quantity of the Tides, on the Precession of the Equinoxes, and on Comets."

The great principle of the *Principia* is universal gravitation, "That every particle of matter in the universe is attracted by or gravitates to every other particle of matter, with a force inversely proportional to the squares of their distances." By the laws of gravity, Newton was enabled to calculate the quantity of matter in the sun, and in all the planets, and even to determine their density, results which Adam Smith said "were above the reach of human reason and experience." He ascertained that the weight of the same body would be twenty-three times greater at the surface of the sun than

at the surface of the earth, and that the density of the earth was four times greater than that of the sun. He found the true figure of the earth; he explained the phenomena of the tides.

Of the "Principia," Sir David Brewster says, in his able life of Sir Isaac Newton, it is "a work which will be memorable not only in the annals of one science or of one country, but which will form an epoch in the history of the world, and will ever be regarded as the brightest page in the records of human reason, – a work, may we not add, which would be read with delight in every planet of our system, – in every system of the universe. What a glorious privilege was it to have been the author of the 'Principia'!"

"There was but one earth upon whose form, and tides, and movements, the philosopher could exercise his genius, – one moon whose perturbations and inequalities and actions he could study, – one sun whose controlling force and apparent motions he could calculate and determine, – one system of planets whose mutual disturbances could tax his highest reason, – one system of comets whose eccentric paths he could explore and rectify, – and one universe of stars to whose binary and multiple combinations he could extend the law of terrestrial gravity.

"To have been the chosen sage summoned to the study of that earth, these systems, and that universe, the favored lawgiver to worlds unnumbered, the high priest in the temple of boundless space, – was a privilege that could be granted but one member of the human family; – and to have executed the last was an achievement which, in its magnitude, can be measured only by the infinite in space, and in the duration of its triumphs by the infinite in time. That sage, – that lawgiver, – that high priest was Newton."

The "Principia" created the greatest interest throughout Europe, but met with violent opposition. While Laplace said it would take "pre-eminence above all the other productions of human genius," the majority could not believe that great planets were suspended in empty space, and retained in their orbits by an invisible power in the sun.

When Newton presented copies to the heads of colleges, some of them, Dr. Babington of Trinity among the number, said, "they might study seven years before they understood anything of it."

In 1687, Newton's method of fluxions was first published, twenty years after its invention, and then because the friends of Leibnitz, the author of the "Differential Calculus," claimed priority of discovery. The quarrel aroused the scientific world, embittered the silent mathematician, and impaired his health.

In 1689, when he was forty-seven, he was chosen member of parliament, and represented Cambridge University in the House of Commons for thirteen months. He took no active part in the debates, but was of course respected for his wonderful mind.

This same year, his beloved mother died. Anxiously he had watched through whole nights by her bedside, seeking in all ways to keep her from leaving him alone in the world.

He was now nearly fifty. His life had been laborious, with an insufficient income. His friends, John Locke among the number, tried to obtain various positions for him, but failed. They recommended him for provost of King's College, but the position could not be obtained because he had not taken priest's orders.

Seemingly unappreciated, worn with his incessant brain work, his appetite failing, and unable to sleep, with neither mother nor wife to comfort him, the sensitive organization of the great man became overstrained, and mind and body were unfitted for work. It is stated that his ill health was in part consequent upon the burning of some manuscripts on optics, by a lighted candle on the table among his papers.

When he was fifty-three, the long hard road of poverty turned into a highway of plenty, through the influence of a friend. Charles Montague, an associate of Newton at the university and also in parliament, though nineteen years his junior, – intellectual affinities are uninfluenced by age, – had been made Commissioner of the Treasury, then Privy Councillor, then Chancellor of the Exchequer, and later still, Baron of Halifax.

Lord Halifax appointed Newton to be Warden of the Mint, and then Master, with an income of between six thousand and seven thousand five hundred dollars annually, which position he held for the remainder of his life. His home in London, where he kept six servants, with his brilliant niece, Miss Catherine Barton, for his companion, became a place of rest and comfort to the tired philosopher. Lord Halifax was a great admirer of Newton's niece, Miss Catherine Barton, to whom he left, at his death, a beautiful home and twenty-five thousand dollars, "as a token of the sincere love, affection, and esteem I have long had for her person, and as a small recompense for the pleasure and happiness I have had in her conversation."

The days of privation were over, and Newton had earned this rest and prosperity. Great people often came to dine with him. At one of his dinners, Newton proposed to drink, not to the health of kings and princes, but to all honest persons, to whatever country they belonged. "We are all friends," he added, "because we unanimously aim at the only object worthy of man, which is the knowledge of truth. We are also of the same religion, because, leading a simple life, we conform ourselves to what is right, and we endeavor sincerely to give to the Supreme Being that worship which, according to our feeble lights, we are persuaded will please him most."

Other honors now come to Newton. In 1703, he was elected President of the Royal Society, and was annually reelected during the remaining twenty-five years of his life. On April 16, 1705, when he was sixty-three, Queen Anne conferred the honor of knighthood upon her most illustrious subject, Sir Isaac Newton, before a distinguished company at Cambridge University. In 1704, the year previous, his great work on optics had been published, written over twenty years before.

About this time, it seems that the great philosopher would have liked to marry Lady Norris, the widow of Sir William Norris, Baronet of Speke, and Member of Parliament. Sent to Delhi as ambassador to the Great Mogul, he died in 1702, between Mauritius and St. Helena, on his homeward passage. He was the third husband to Lady Norris, and Sir Isaac, now over sixty, desired to be the fourth, as appears from the following letter: —

"Madam, — Your ladyship's great grief at the loss of Sir William shows that if he had returned safe home, your ladyship could have been glad to have lived still with a husband, and therefore your aversion at present from marrying again can proceed from nothing else than the memory of him whom you have lost. To be always thinking on the dead, is to live a melancholy life among sepulchres, and how much grief is an enemy to your health, is very manifest by the sickness it brought when you received the first news of your widowhood. And can your ladyship resolve to spend the rest of your days in grief and sickness?

"Can you resolve to wear a widow's habit perpetually, — a habit which is less acceptable to company, a habit which will be always putting you in mind of your lost husband, and thereby promote your grief and indisposition till you leave it off? The proper remedy for all these mischiefs is a new husband, and whether your ladyship should admit of a proper remedy for such maladies, is a question which I hope will not need much time to consider of.

"Whether your ladyship should go constantly in the melancholy dress of a widow, or flourish once more among the ladies; whether you should spend the rest of your days cheerfully or in sadness, in health or in sickness, are questions which need not much consideration to decide them. Besides that your ladyship will be better able to live according to your quality by the assistance of a husband than upon your own estate alone; and, therefore, since your ladyship likes the person proposed, I doubt not but in a little time to have notice of your ladyship's inclinations to marry, at least, that you will give him leave to discourse with you about it.

"I am, madam, your ladyship's most humble and most obedient servant."

If Lady Norris "liked the person proposed," as Sir Isaac imagined, a marriage was not the result. It is just possible that he was like Leibnitz, who proposed to a lady when he was fifty. The lady asked for time to take the matter into consideration, and as Leibnitz thus obtained leisure to consider the matter again, he was never married.

For thirteen years Sir Isaac lived on Jermyn Street, London; then moved to Chelsea, a place dear to those who love George Eliot or admire Carlyle; and then to Martin Street, near Leicester Fields.

In his latter years he wrote much on theological subjects, especially to prove the existence of a Deity. When he was eighty-three he published a third edition of the "Principia." At eighty-five he read manuscript without spectacles. He reasoned as acutely as ever, his memory alone failing.

On March 2, 1727, he presided at a meeting of the Royal Society. He was taken ill on the following day, and, although a great sufferer for several days, never uttered a complaint. He died on Monday, March 20, and his body was laid in the Jerusalem Chamber, and thence conveyed to Westminster Abbey for burial. The pall was supported by the Lord High Chancellor and several Dukes and Earls.

On the front of his monument are sculptured youths, bearing in their hands emblematic designs of Newton's principal discoveries. One carries a prism, another a reflecting telescope, a third is weighing the sun and planets with a steelyard, a fourth is employed about a furnace, and two others are loaded with money newly coined. The monument bears this inscription.

Here Lies

SIR ISAAC NEWTON, KNIGHT,

Who by a vigor of mind, almost supernatural,

First demonstrated

The motions and figures of the Planets,

The Paths of the Comets, and the

Tides of the Ocean

He diligently investigated

The different refrangibilities of the Rays of Light,

And the properties of the Colors to which

they give rise

An Assiduous, Sagacious, and Faithful Interpreter

of Nature, Antiquity, and the Holy Scriptures,

He asserted in his Philosophy the Majesty of

God, and exhibited in his Conduct the

simplicity of the Gospel

While he gave generously during his life, he said, "they who give nothing till they die, never give at all," – he left a personal estate of one hundred and sixty thousand dollars, to be divided among his nephews and nieces.

The world honored him at last, and has through all the years. Bishop Burnet said, "Newton had the *whitest* soul he ever knew." His habits were of the best. When asked to take snuff or tobacco, he declined, saying, "he would make no necessities to himself."

He was modest to the last, saying, "that whatever service he had done the public was not owing to any extraordinary sagacity, but solely to industry and patient thought." He said, a short time before his death: "I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

CARL LINNÆUS

It was on the 24th of July that we left Stockholm, the Venice of the North, built on her nine islands, for the famous university town of Upsala, Sweden. The ride, of about two hours by rail, lay along fine fields of wheat, blue with corn-flowers, and past comfortable-looking red farmhouses and barns.

The town, of thirteen thousand people, is quaint and quiet, yet most interesting to a stranger. We wander over the grand old Gothic cathedral, begun six hundred years ago. Here is the silver-gilt sarcophagus of King Eric IX., who died in 1160, and of John III. Here, also, that of Gustavus Vasa, the deliverer of Sweden, on a high marble pedestal supported by pillars, a recumbent figure of a wife on either side. A third wife is buried near by. The walls of the chapel where he lies are covered with frescoes, depicting scenes in that wonderful life; from the rags of the miner, to the sumptuousness of the throne.

But especially are we interested in a plain slab, underneath which sleeps the man who, more than any other, has immortalized Upsala University, and helped to make Sweden an intellectual and studious country. Near by is the monument of dark porphyry, with the plain, shaven face in bronze, wreathed with laurel, and the words "*Carolo a Linné Botanicorum Principi Amici et Discipuli, 1798.*"

Then we turn our steps to the University, the pride and hope of Sweden. Here fifteen hundred gather, not in dormitories – which were tried fifty years ago and discarded – but scattered in various homes, as in the German universities. Women are educated here on equal terms with men, and we are assured by the professors that, though admitted only a few years ago, their presence is most helpful, and the plan has proved entirely successful. No duels are allowed, these having been abolished by stringent laws two hundred years ago; a thing Germany should long since have done, and thus ended this brutal custom.

Here is the Astronomical Observatory, the Chemical Laboratory, Anatomy Building, Academic Department, and handsome library with two hundred thousand volumes and over seven thousand manuscripts. Here we look at the celebrated "Codex Argenteus," a translation of the four Gospels by Bishop Ulfila, dating from the second half of the fourth century, written on one hundred and eighty-eight leaves of parchment – gold and silver letters on a reddish ground; and the manuscript of Frithiof's Saga, by Tegnér.

Now we visit the Botanic Garden, which Linnæus so loved and developed, and go over the two-and-a-half-story stuccoed house, cream-colored, where the great naturalist lived and entertained princes. Under these dark poplars, enormous in size, he taught the pupils who came from all parts of the world to hear him. The dark, closed blinds are as he left them, for Sweden would not change one thing about the precious home. Too little in our own country do we treasure the homes of those who give honor to the nation.

The history of Linnæus is, indeed, a romance. Few have had such great struggles with poverty; few have come off such conquerors. Few lives have given to the world such lessons of cheerfulness, of perseverance, and of untiring industry. He was born, May, 1707, at Rashult, in the south of Sweden, the son of a poor minister, and the eldest of five children. The father, Nils Linnæus, had obtained his education by the hardest toil, and, while he had only poverty to offer his family, he gave them what money could not buy, tender affection, and the inspiring influence of a cultivated mind that loved nature and studied her closely. His mother, Christina, a woman of sense, prudence, and good judgment, was his idol. He wrote of her in later years: "She possessed all the virtues of her sex, devoting the utmost attention to impressing on my mind the love of virtue, both in precept and example."

From a child he was fond of his father's garden, and gathered from the fields all kinds of wild flowers. He says of himself in his autobiography: "He was scarcely four years old when he

accompanied his father at a feast at Mökler, and in the evening, it being a very pleasant season of the year, the guests seated themselves on some flowery turf, listening to the pastor, who made various remarks on the names and properties of the plants, showing them the roots of the succisa, tormentilla, orchids, etc. The child paid the most uninterrupted attention to all he saw and heard, and from that hour never ceased harassing his father about the name, qualities, and nature of every plant he met with; indeed, he very often asked more than his father was able to answer, but, like other children, he used immediately to forget what he had learned, and especially the *names* of plants. Hence the father was sometimes put out of humor, and refused to answer him unless he would promise to remember what was told him. Nor had this harshness any bad effect, for he afterward retained with ease whatever he heard."

When he was eight, a piece of ground was assigned him, which was called "Carl's Garden." Here he gathered plants and flowers, and introduced so many rare weeds that his father had great trouble in eradicating them! So interested did Carl become, that he had nests of wild bees and wasps, not agreeable playthings usually.

But the play days with weeds and wasps came to an end, for the bright boy had to go to school. His first teacher was "a passionate and morose man, better calculated for extinguishing a youth's talents than for improving them," and the next "pursued the same methods, preferring stripes and punishments to encouragements and admonitions." There was little time now for the precious study of flowers. At seventeen he had to go to a gymnasium or high school, where he would be taught classics, and made ready for the ministry, like his father. He had no fondness for the languages, neither for theology or metaphysics: but having obtained two books on botany, he read them day and night, committing them to memory. The teachers and scholars called him "the little botanist."

What was his father's chagrin, when he came to the school to visit him, to hear that Carl was quite unfit for the ministry, but would probably make a good tailor or shoemaker! Poor as he was, he had kept his boy at school for about twelve years. Now, well-nigh disheartened, he stopped, on his way home, to confer with his family physician, Dr. Rothmann. That good man suggested that the boy might like medicine, and accomplish great things in natural history. He offered to take him into his own home, and give him lessons in physiology, which kind proposal the father accepted, though with little faith. The doctor also taught him botany, and Carl grew happy under the new *régime*.

The next year he was sent to the University of Lund, with the following not very creditable certificate from the head master of the Gymnasium: "Youth at school may be compared to shrubs in a garden, which will sometimes, though rarely, elude all the care of the gardener, but if transplanted into a different soil, may become fruitful trees. With this view, therefore, and no other, the bearer is sent to the University, where it is possible that he may meet with a climate propitious to his progress." Through a friend, entrance was obtained without showing the obnoxious certificate.

Carl took lodgings at the house of Dr. Stobæus, physician to the king, who gave him access to his minerals, shells, and dried plants. Delighted at this, the youth at once began to make a collection of his own, and glue them on paper. He longed to gain access to Dr. Stobæus's library, but how should it be accomplished? Finally a young German student, to whom he taught physiology, surreptitiously gained the books needed, and young Linnæus spent nearly the whole nights in reading. The doctor's aged mother did not understand why their lodger kept his light burning into the small hours, and besought her son to investigate. He did so, and found the crestfallen Carl reading his own library books. He forgave the student, took him to his own table and treated him as a son.

Advised by Dr. Rothmann to go to Upsala for better medical opportunities, he proceeded thither, and here began his bitterest poverty. His father could give him only forty dollars. As he was unknown, and without influence, he could obtain no private pupils. Starvation actually stared him in the face. He says, "he was obliged to trust to chance for a meal, and in the article of dress, was reduced to such shifts that he was obliged, when his shoes required mending, to patch them with

folded paper, instead of sending them to the cobbler." Often hungry and half clothed, there seemed nothing before the poor Swedish lad but obscurity and early death.

One day in autumn, as he was examining some plants in the Academical Garden, a venerable clergyman, Dr. Olaf Celsius, saw him, and asked him where he came from, how long he had been at the college, and what he knew about plants. He, too, was interested in botany, and was preparing a work on the plants mentioned in the Bible. Perhaps something in Carl's face or manner touched the minister's heart, for he asked him to go home with him, and soon offered him board in his own house, and gave him access to his valuable library.

The tide of adversity was beginning to turn. Some pupils were obtained, and a little money flowed into the empty pockets. At twenty-two, by a close examination of the stamens and pistils of flowers, he decided upon a new method of arrangement by the sexes of plants, which, in after years, became the basis of his great fame. This procured him the appointment of Assistant Lecturer to Dr. Rudbeck in the Botanical Garden, where, but a year before, he had asked to be the gardener!

He still had little money, but, what was equally useful, some leisure time. He began his great works, which were not completed for seven years, "Bibliotheca Botanica," "Classes Plantarum," "Critica Botanica," and "Genera Plantarum," "letting," as he said, "not a minute pass unoccupied during his residence at Upsala. For the latter work he examined the characters of eight thousand flowers."

Scarcely had he begun this valuable labor, when the envy of one of the professors became as hard to bear as his previous poverty, and, through friends, he obtained an appointment to study the natural history of Lapland. It was a hazardous expedition for a young man of twenty-five. Now he climbed steep rocks, "which," he says, "broke loose from a spot which my late guide had just passed, and fell exactly where I had been, with such force that it struck fire as it went." Once, when floating down a river, the raft parted in the middle, and he narrowly escaped drowning. "All my food," he says, "in those fatiguing excursions, consisted, for the most part, of fish and reindeer's milk. Bread, salt, and what is found everywhere else, did but seldom recreate my palate." He travelled nearly four thousand miles, mostly on foot, often through bogs and marshes, with the water to his knees, yet always cheerful, always enthusiastic. On presenting his report to the University, on his return home, they gave him about fifty dollars for his travelling expenses for five months!

A single incident shows the tender heart of the young explorer. Very few birds were visible except the ptarmigan. He says: "The little Alpine variety of the ptarmigan was now accompanied by its young. I caught one of these, upon which the hen ran so close to me that I could easily have taken her also. She kept continually jumping round and round me, but I thought it a pity to deprive the tender brood of their mother; neither would my compassion for the mother allow me long to detain her offspring, which I returned to her in safety." Tenderness to animals seems to be a striking characteristic of great men and women.

During the journey, he found a modest little flower in the great northern forests, in the moss, and this he named *Linnæa borealis*, thinking it was so like himself, expanding in obscurity. He chose for his motto, *Tantus amor florum*, "So great is the love for flowers."

On his return to Upsala, he began courses of private lectures in medicine, but so bitter was the envy of the before-mentioned professor that the archbishop was prevailed upon to prohibit private lectures. Thus deprived of a livelihood, Linnæus turned his attention to mineralogy, visiting the Swedish mines. The Governor of Dalecarlia was so pleased with him that he engaged him to investigate the productions of his country. Here he fell in love with the daughter of John Moræus, a well-to-do physician.

Sara Elizabeth reciprocated the affections of the young man, who was told by the father that he must wait three years for a final answer; for, in truth, Linnæus's financial prospects were not bright. The University of Upsala did not want him, and there seemed to be no hope of writing or publishing

his books on botany. But a man usually achieves little, who does not fight his way at every step. Now, indeed, for love's sake he must make his mark.

After saving about seventy-five dollars, he decided to go to Germany, and take his doctor's degree; but first he must visit his home, out of which his beloved mother had gone at forty-five. "Alas! alas, my mother!" was all he could say, as the tears fell fast upon her grave. She had witnessed his poverty and his heroism; she was not to witness his great renown.

At Hamburg he spent a month, receiving civilities from many scientific men. He showed his good sense in feeling in no wise humiliated because he was poor, a valuable lesson for poor young men and women to learn. At Leyden, good fortune came to him. Dr. Gronovius was so pleased with the manuscript of his "Systema Naturæ" that he requested to publish it at his own expense. By his advice, Carl waited upon the celebrated physician, Boerhaave, and after eight days gained admittance. So famous was this man that when the Emperor of China sent a letter to "Boerhaave, the famous physician in Europe," it easily reached him. He advised a rich banker, Mr. Clifford, to have Linnæus describe his magnificent collection of plants, and to send him to England and elsewhere, to collect specimens for him. This was indeed a blessing. "Here in England," he says, "I lived like a prince, and had one of the finest gardens of the world under my inspection." A society in Amsterdam advanced the money to pay for the plates for his "Flora Lapponica," and fame seemed really to be coming at last.

In his visit to England, Sir Hans Sloane, who founded the British Museum, looked upon him coldly because he had suggested a different system in natural history from his own! At Oxford, Dillenius said to friends, sarcastically: "See, this is the young man who confounds all botany!" Linnæus felt hurt, and, when about to take his departure from the city, asked the scientist why he had treated him thus. After the young student had explained his work, Dillenius became his warm friend, and pressed him to stay, and even to share his salary with him. Linnæus was greatly pleased with London, and when he saw the golden furze in its green leaves, fell on his knees before it.

On his return to Germany he went to the death-bed of Boerhaave, whose parting words were: "I have lived out my time and done what I could. May God preserve thee, from whom the world expects much more! Farewell, my dear Linnæus!"

He now hastened to the idol of his heart in Sweden, and what was his amazement to find that the friend to whom he had intrusted his correspondence with Sara Elizabeth had been trying to win her for himself! Perhaps it would have been quite as well for Linnæus had he succeeded! However, matters were amicably adjusted, and the long waiting lover became engaged.

He repaired at once to Stockholm to begin the practice of medicine, still keeping as near Upsala University as possible. And here troubles began anew. He says: "Being unknown to everybody, people were unwilling to trust their lives in my hands. Nay, they even hesitated to trust me with their dogs! Abroad, I had been honored in every place as Princeps Botanicorum; but in my own country I was looked upon as a *Klim*, newly arrived from the subterranean regions! No one cared how many sleepless nights and toilsome hours I passed. Had I not been in love I would certainly have left Sweden and gone abroad."

After a time a fortunate cure effected by him brought him speedy popularity. "No invalid could now recover without my assistance. I was busy from four in the morning till late in the evening; nor were my nights left undisturbed." He was soon chosen a member of the Upsala Academy, and at the request of the king, through his tutor, Count Tessin, gave public lectures on botany and mineralogy.

And now the rising botanist desired to claim his bride. They were accordingly married June 26, 1739, when Linnæus was thirty-two. Dr. Moræus had waited long enough to see that his daughter was making no mistake. Life now flowed on smoothly. If the "little wife," as he called her, governed him with no very gentle sway in after years, she had great influence over him, and it is said that at her instigation he persecuted his only son. All the more is Linnæus to be admired for accomplishing such a grand work with domestic hindrances. It takes a very great man to be great when his home is not a help to him! However, he always regarded her as "one of the choicest gifts bestowed upon him."

His medical practice brought him plenty of money, but he wrote to a friend: "Once I had plants and no money: now what is money good for without plants?" Soon the desire of his heart was granted, and he was made Professor of Botany at Upsala University, also superintendent of the Botanical Garden.

Now he says: "I render thanks to the Almighty, who has ordered my lot so that I live at this day; and live, too, happier than the King of Persia. I think myself thus blessed because in this academic garden I am principal. This is my Rhodus, or, rather, my Elysium; here I enjoy the spoils of the East and the West, and, if I mistake not, that which far excels in beauty the garments of the Babylonians and the porcelain of China."

His fame grew rapidly. He published, in 1745, his "Flora Suecica," and a year later his "Fauna Suecica," a description of Swedish plants and animals. His lectures soon, by their enthusiasm and eloquence, brought listeners from all parts of Europe. The number of students in the university grew from five hundred to fifteen hundred, young men coming even from America to hear the great botanist. During the summer he made excursions twice a week, often at the head of two hundred students, and when some rare plant was discovered, the news was announced to the others by horn or trumpet. His scholars, imbued with his spirit, went over the world in scientific investigation. Some died in the Arabian deserts; some in the swamps of Africa. From foreign students he would take no fee, as he desired to show them how he loved his work. Once he said to a German student: "Tell me, candidly, are you rich, and can you afford it? If you can, then give the money to my wife; but, if you be poor, so help me Heaven, I will not take a single farthing from you!"

Most of the scientific societies of Europe made him a member after his great works were published. The Imperial Academy called him "Dioscorides Secundus"; a gold medal was struck in his honor in 1746, and the king made him dean of the College of Physicians. He published two valuable medical books, and received the honor of the Knight of the Polar Star, never before conferred for literary merit. He was made a noble, and took for his motto, *Famam extendere factis*, adorning his crest with the little flower which he discovered in his poverty. He was made rector of the university, holding the position for several years. How different from the time when he could obtain only a chance meal, and covered up the holes in his torn shoes!

He bought two estates, living at one of them – Hammerby – for fifteen years. In 1774, when he was sixty-seven, he suffered an attack of apoplexy in the Botanical Garden, and, two years later, another stroke made him a paralytic. When he could no longer walk, he used to be carried to his museum, and look long and earnestly at his treasures, gathered from every clime. His memory so failed him that he mixed the Greek and Latin letters, and forgot even his own name. On the 10th of January, 1778, death came to him in his sleep.

The university went into mourning, the king made a public address, and the whole nation regarded it as an irreparable loss. His herbarium and library were sold, after a time, by the wife, to Sir James E. Smith, the founder of the Linnæan Society, of London, where these treasures are now to be seen, and most of the one hundred and eighty works which he published during forty-five years. It is said that the King of Sweden, on learning that the work of Linnæus was going out of the country, sent a man-of-war to recover it, but without avail.

Linnæus was small in body, with large head, and the bright, piercing eyes which usually characterize men and women of genius.

Of his six children, the oldest soon became professor of botany, to assist, and then succeed, his father, but he lacked the parent's just and honorable love of fame. The eldest daughter inherited much of his ability, being the first to discover the luminous property of the nasturtium flowers at night. Sara Elizabeth survived her noble husband many years, and now lies beside him in the cathedral.

BARON CUVIER

In the town of Montbéliard, France, then belonging to the Duke of Würtemberg, August 23, 1769, was born the founder of the Science of Comparative Anatomy; the greatest naturalist of his time, Georges Léopold Chrétien Frédéric Dagobert Cuvier. His father was a brave officer in a Swiss regiment, who at fifty married a young lady of unusual ability. Their first son died, and the second, Georges, was so feeble in constitution that his life was saved only by the tenderest care of his mother.

For this mother the boy cherished the most ardent affection. While she lived, there was nothing left undone that a loving nature could do for her. When she died, everything connected with her memory became sacred. When Cuvier had become honored by kings and nobles, when the great from all the world delighted to bring him offerings, nothing so touched his heart as the gift of a bouquet of red stocks, her favorite flower. Perchance the benignity that came into his face in later years was the result of these sweet remembrances.

She taught him to read at four, and, though ignorant of Latin, she made him repeat his lessons to her daily, so that he was the best prepared of any boy in school. She read to him history and general literature. She made him draw under her inspection. She talked with him about books till a passion for reading became the chief characteristic of his nature. No wonder that he loved such an inspiring woman. The history of most great men emphasizes the fact that the mothers cannot be too highly educated. At ten years of age he was placed in a high school, called a Gymnase, where for four years he studied Latin, Greek, history, geography, and mathematics, and was constantly at the head of his classes. Naturally enthusiastic, he played as heartily as he studied.

As is often the case, a book turned the course of his life, and made him famous. At the Gymnase he found a work of Gesner, the Swiss naturalist, and this, with its colored plates, first turned his attention to natural history. This liking was intensified by finding at the house of a relative the complete works of Buffon, the noted naturalist, who wrote thirty-six volumes in his own brilliant and poetic style, describing the animal kingdom. The boy became intensely interested in the habits of quadrupeds and birds; their form, their color, and their homes. He copied the illustrations in the work, and colored them with paint or pieces of silk. He always carried a volume of Buffon in his pocket to read when he had a moment of leisure. At twelve, he was a well-read naturalist.

In his last year in the Gymnase, when he was fourteen, he chose a certain number of his school-fellows, and formed an Academy. Every Thursday he gathered the lads into his room, and placing them around a table, seated himself upon his bed, and after some book had been read on natural history, philosophy, history, or travels, he asked their opinions of it, and then, being president, summed up the argument in a clear and concise manner. The mother's seed-sowing in the mind of her ardent boy was bearing fruit.

As the family were poor, and had only a soldier's pension to support them, it was decided that Georges should enter the free school at Tübingen, and prepare for the church. But the principal of the Gymnase, who had never forgiven the boy for some playful trick, placed his composition in the third rank. Georges knew that it deserved the first rank, and that this low standard would affect his position in college. He, therefore, resolved not to enter Tübingen, and, though he was thereby lost to the church, he was saved for great scientific work.

A fortunate thing now happened. A woman, a princess, who knew about the bright boy, spoke of him to her brother, Duke Charles of Würtemberg. When the duke visited Montbéliard, he sent for the lad, questioned him as to what he had learned, asked to see his drawings, and ended by sending him free of expense to the University of Stuttgart, to enter his own Academy, called the Academy Caroline. It seemed a little thing for a lady to speak of a boy's studiousness and great love of books, but it proved a great thing for Georges Cuvier and for the scientific world. Thousands of women and men could do more of these little acts of kindness, if they only thought of it. Well said Thomas Hood: —

"Evil is wrought by want of thought,
As well as want of heart."

The boy of fourteen said good-by to his devoted mother, and started for Stuttgart, seated between the Chamberlain and the Secretary of the Grand Duke. Both spoke German all the way, and the lonesome boy did not understand a word. He entered the Academy May 4, 1784, and for four years studied mathematics, law, philosophy, finance, and the like.

But he lost no opportunity to study natural history. A professor gave him the works of Linnæus, and he gained inspiration from the young man who could travel four thousand miles through the marshes of Lapland, nearly barefoot and half-starved, in his study of plants. Georges now collected a herbarium. When he had leisure, he drew and colored insects, birds, and flowers with great accuracy. He kept a number of living insects in his room, constantly feeding them, and watching their habits. He said years afterward, "If I had not studied insects from choice, when I was at college, I should have done so later, from a conviction of its necessity." He declared that the wonders he met with in the organization of insects always elevated his thoughts.

Nine months after his arrival in Germany, he won the prize at the Academy for excellence in the German language, receiving the order of Chevalerie, an honor given only to five or six out of four hundred pupils. This entitled the recipients to dine at a separate table, and to enjoy many advantages under the immediate patronage of the Grand Duke.

When the four years of college life were over, the father's pension having ceased on account of the disturbed financial condition of France, the youth of eighteen needed to find employment at once. Nothing seemed open to him but the position of tutor in a private family, a thing much deprecated by his school-fellows, who had already built many air-castles for his future.

But young Cuvier had the courage and the wisdom to do what necessity required, and to do it cheerfully. In July, 1788, he entered the family of Count d'Héricy in Caen, Normandy, and for six years taught his only son. He took with him, says a friend, "these admirable foundations for glory: a love of labor, depth of reflection, perseverance, and uprightness of character." While teaching here, he met the nobility of the surrounding country, increasing thereby his polish of manner and tact, for which he was celebrated all his life.

Living by the sea, he was led to study marine animals. The casual dissection of a calamar, a species of cuttle-fish, influenced him to study the anatomy of mollusca, which afterward led to his great classification of the whole animal kingdom. In this obscure corner of Normandy, the young teacher observed, and committed his observations to paper. Some young men would not have found time for such work. Those only succeed who have sufficient force of character to make time for what they wish to do. To allow one's time to be wasted, is to allow one's opportunities for eminence to go by forever.

Nearly every evening Cuvier attended a small society of which he was secretary, which gathered chiefly to discuss agricultural and kindred topics. M. Tessier, living there in exile under an assumed name, the author of several valuable articles in the Encyclopedia, was often present, and between him and the young secretary a warm friendship soon existed. As the friendship of the Marquis Guidubaldo proved valuable to Galileo, so that of M. Tessier proved of great benefit to Cuvier. He led the young and comparatively unknown naturalist, though some of his articles had been published in learned journals, to correspond with Geoffroy St. Hilaire, De Lacépède, and others on scientific subjects. Through their influence he was finally called to Paris, made a member of the Commission of Arts, and professor at the Central School of the Panthéon.

He was only twenty-six, and this was but the beginning of honors. Here he composed his "Elementary Treatise on the Natural History of Animals." His great desire was to be attached to the Museum of Natural History, where he could study the collections and enlarge them. Very soon after

his arrival in Paris, M. Mertrud was appointed to the newly created chair of Comparative Anatomy at the Jardin des Plantes. He was advanced in years. And now came the opportunity for friendship to do its work. Geoffroy St. Hilaire and De Lacépède were his colleagues. They urged that their friend Cuvier be appointed assistant, and Mertrud gladly consented. This was indeed an honor, since Daubenton, Buffon, Lamarck, and other European celebrities had filled this position.

Cuvier at once sent for his aged father, now nearly eighty years old, and his only brother, Frédéric, to make their home with him. The precious mother had died two years previously. She did not live to see the fame of her eldest son, but she must have been convinced of his future greatness, and been comforted by the prospect.

From the moment of entering upon his new work, Cuvier began to develop that wonderful collection in comparative anatomy which is now so celebrated. Nothing ever turned him from his purpose of making this the most extensive collection in the world; no sorrow, no legislative duties, no absence. No one who has visited Paris will ever forget the seventy-five acres in the Jardin des Plantes, with trees and flowers from all the world; with thirteen rooms filled with skeletons and anatomical preparations of all kinds; with eleven rooms in the gallery of anthropology containing every variety of the human species, in casts, mummies, and fossils; with the gallery of zoölogy containing over two thousand mammalia, belonging to five hundred species, as many reptiles, ten thousand birds, and over twenty-five hundred fishes; with immense geological, mineralogical, and botanical collections; all a marvel of industry and learning.

Cuvier now worked unceasingly. Sometimes his salary was in arrears, but he bore it cheerfully, as he wrote a friend: "You are not to suppose that Paris is so highly favored; for twelve months' pay are now due at the Jardin des Plantes, and all the national establishments for public instruction, in Paris as well as at Strasburg; and if we envy the elephants, it is not because they are better paid than we are, but because while living on credit, as we do, they are not aware of it, and consequently are insensible to the pain it gives. You know the saying about the French, that when they have no money they sing. We savants, who are not musicians, work at our sciences instead of singing, which comes to the same thing." He is a hero, indeed, who can breast poverty, and work and sing in the midst of hardship. When he published his "Annals of the Museum," he not only drew, but often engraved the plates himself, when he was unable, for lack of means, to hire it done.

The National Institution was founded in 1796, and Cuvier was associated with his friends De Lacépède and Daubenton, in the section of zoölogy, holding the position of Secretary of Natural Sciences till his death.

Four years later, in 1800, the first two volumes of his "Lessons in Comparative Anatomy" were published, and met with great success. The last three volumes were issued five years later.

In this year, 1800, Cuvier received another honor, that of the professorship of Natural Philosophy in the Collège de France. He was now but thirty-one. The following year, Napoleon I., who was usually wise in his selection of men, appointed him one of the six inspectors-general of education, to establish public schools in thirty towns of France.

Every moment now seemed occupied, and yet while the brain was busy perchance the heart was lonely. The father had died two years after the mother. The wife of his brother Frédéric had died, also, and the two brothers were left alone. At thirty-four, Cuvier decided to take into his heart and home the widow of M. Duvaucel, Fermier-Général, who had perished on the scaffold in 1794. The family had lost all their money in the French Revolution, and Madame Duvaucel had four large children to be supported; but Cuvier loved her for her rare mind and sweet disposition, and she blessed the remaining years of his life. An educated man needs companionship in mind; not simply a housekeeper.

Six years later one of her sons was assassinated in Portugal, during the retreat of the French army. Another, while collecting for the Museum of Paris, died in Madras, a young man of great talent and much beloved. A daughter, Mlle. Duvaucel, lived to be the comfort of Cuvier's declining years.

Happy in his home and absorbed with his work, Cuvier went forward to new labors and new honors. M. Mertrud had died, and, instead of being assistant at the Jardin des Plantes, Cuvier was now professor. In 1808 Napoleon made him counsellor for life of the Imperial University. The next year he organized new academies in the Italian States, which were now annexed to France. In 1811 he was sent on a similar mission to Holland and the Hanseatic towns, and was made a chevalier, which rank was assured to his heirs. Though he disliked to be absent from his family, he went where duty called him, and wrote back fond letters to his wife.

"My Tender Friend, – The weather, the road, the horses, and the postilions have proved so excellent that we have reached Porte Sainte Mayence before six o'clock; and I have bitterly regretted the two or three good hours that I might still have passed with thee, without in the least delaying my journey. At least believe that I have passed them in my imagination, and that the remembrance of thy caresses and tender friendship will form the happiness of my whole way." After some words to the children, he added, "We are quite well, my good friend; we have crossed an agreeable country; and we are in a tolerable inn. Our carriage appears to be quite able to bear the journey; thus, up to this moment, all goes well. Pray to God that this may last; thou art so good that he cannot refuse thee. Adieu. A thousand tender kisses. G. C."

This year, 1811, appeared one of his most important works – that on "Fossil Remains," which wrought a revolution in the study of geology. By comparing living and fossil animals, Cuvier showed that huger creatures had lived on the earth and become extinct before the creation of man. In the first epoch he found great reptiles, like the Ichthyosaurus, thirty feet long, and the Megalosaurus, seventy feet long. In the second epoch, he found the Paleotherium; in the third, the Mammoth, Mastodon, and gigantic sloth; and in the fourth epoch, man. So closely had he studied the relations of the organs of animals, that he could reconstruct the extinct fossil from a single bone. He had already prepared, at the request of Napoleon, a brilliant "Report on the Progress of Natural Sciences from the year 1789."

In 1813, though a Protestant, he was sent to Rome to organize a university, and was made Master of Requests in the Council of State. Napoleon also appointed him Commissaire Impérial Extraordinaire, and sent him to endeavor to raise the people on the left bank of the Rhine in favor of France, against the invading troops then marching upon them. But Cuvier was stopped at Nancy by the entrance of the allied armies, and obliged to return.

He was now famous, and his company and counsel were sought by the learned and the great. And he was still a comparatively young man, forty-four.

But life had great sorrows in the midst of this prosperity. His first child, a son, had died a few weeks after his birth. His daughter Annie had died in 1812, at the age of four, and now in 1813, while he was absent in Rome, his only son, Georges, a boy of seven, had been taken from him. The blow was a terrible one. For many years he never saw a boy near that age, without being deeply affected. He would stop on the streets to watch a group of boys playing, and then go on sadly, thinking of the one he had buried.

In 1814, Cuvier was raised to the rank of Counsellor of State, and Chancellor of the University. When Napoleon was asked why he had appointed a savant to a political position, he replied, "that he may be able to rest himself sometimes," knowing that to a man like Cuvier change was the most helpful rest. When Napoleon abdicated his throne, and Louis XVIII. came to power, Cuvier was retained in office, for his rare administrative ability, and upright life.

Three years later, the first edition of his "Animal Kingdom" appeared, and is now to be seen in the British Museum, in seventeen volumes. This work has served as the basis for subsequent zoölogical classification. Cuvier studied minutely the interior structure of animals, and based his classification on this, instead of exterior resemblance.

After this great work was published, Cuvier went with his family to London, for a rest of six weeks. Here he received distinguished attention from Sir William Herschel, and other learned men.

In 1819, he was appointed President of the Committee of the Interior, and in this position, which he held for life, it is believed ten thousand various matters passed through his hands each year, for his examination and decision. He officiated at the crowning of Charles X., as one of the presidents of the Council of State, and received from that monarch the decoration of Grand Officer of the Legion of Honor. His former sovereign, the King of Würtemberg, appointed him Commander of the Order of the Crown.

All this time in which he was doing earnest and responsible work for his country, he was writing and lecturing almost constantly. So careful was he of his time, that he always read or wrote as he was riding in his carriage through the streets of Paris. A lamp in the back of his carriage he used at night, till he found that he was injuring his eyes. Even while he was sitting for a portrait, to be used as a frontispiece for his book, "Discourse on the Revolutions of the Globe," his wife's daughter read to him the "Fortunes of Nigel." In the evenings, when he was too tired for scientific research, his wife or daughter read to him general literature.

Every Saturday evening a reception was held at the home of Baron Cuvier, and there one was sure to meet the most brilliant and learned from all parts of Europe, whether rich or poor...

Cuvier delighted everybody by his courtesy and his cordiality. Another person also was the life of these gatherings, – his beautiful daughter Clementine, his only remaining child. Never strong in body, she had been reared with the tenderest care. Devoted to all good work, reading to aged women, visiting the poor, educated, and of extreme loveliness of character, she was the idol of her family and of society. On the 25th of August, 1828, she was to have been married, but, while in the midst of the preparations, she fell ill of consumption, and died the following month, September 28.

The effect on both parents was crushing. Cuvier's light hair grew white, and lines gathered in his face. After two months he took his place again at the head of the Committee of the Interior. He listened attentively to all the discussions, but when it came his turn to speak, he burst into tears, and covered his bowed face in his hands, and sobbed bitterly. Finally he raised his head and said, "Pardon me, gentlemen, I was a father, and I have lost all!" and then with a violent effort he resumed the business of the day, with his usual calmness.

He devoted himself now more than ever to his books, as though he must use every moment, or be prostrated with grief. This same year, 1828, the first book in a series of twenty volumes, beautifully illustrated, appeared, on the "Natural History of Fishes, containing more than five thousand species of those animals, described after nature, and distributed according to their affinities, with observations on their anatomy, and critical researches on their nomenclature, ancient as well as modern."

In 1832, he was created a Peer of France, by Louis Philippe. Every honor had come that could be asked or desired. His books were eagerly read; crowds attended his lectures; he was loved, honored, and revered; but death had robbed him of the sweetest things in life.

On Tuesday, May 8, 1832, he lectured as usual before the Collège de France, on the "History and Progress of Science in all Ages." In the evening he felt a numbness in his right arm. It was the beginning of the end. Paralysis soon developed.

He said to M. Pasquier, President of the Chamber of Peers, "Behold a very different person to the man of Tuesday – of Saturday. Nevertheless, I had great things still to do. All was ready in my head; after thirty years of labor and research, there remained but to write; and now the hands fail, and carry with them the head."

M. Pasquier tenderly expressed the universal interest felt for M. Cuvier. "I like to think so," said the dying man; "I have long labored to render myself worthy of it." He is to be pitied, indeed, who does not care whether the world loves him.

On May 13, the nomination of Cuvier to the presidency of the whole Council of State was taken to the sovereign for his signature, but it came too late. Cuvier died that day. Four hours before his death he had asked to be taken into the room where he had met and talked with so many of the renowned of earth, and where his Clementine had charmed them by her presence. And there he died.

He was buried in Père la Chaise, by his own request, under the tombstone which covered Clementine, and whose death had virtually caused his own. His coffin was borne by the pupils of the different colleges in which he had taught, thousands following it to the cemetery. His library of nineteen thousand volumes was purchased by the government for the Jardin des Plantes. There was no child left to bear his titles.

Not only do the books of such a man live; his whole life, with its untiring energy, its promptness, its order, its unfaltering purpose, its high aims, as well as its tenderness and nobility of heart, is a constant inspiration.

SIR WILLIAM AND CAROLINE HERSCHEL

In Hanover, Germany, in the year 1732, Isaac Herschel and a plain, industrious girl, Anna Ilse Moritzen, began their home life together. The young man did not like the calling of his father, the cultivating of the royal gardens, and learned to play the oboe in the royal band.

He became skilled in music, and, as, one after another, ten children were born into the little home, he taught them to play on the violin and oboe, and such other branches of knowledge as he possessed. After a time his health became impaired with exposure in the Seven Years' War, and then he earned his living by lessons in music, given to scholars at his home.

The children attended the garrison school in Hanover, and learned the ordinary rudiments, besides French and German. Though the father sometimes copied music half the night to eke out his scanty living, he spared no pains to teach them all he could of his favorite art.

The fourth son, William, born November 15, 1738, not only learned French and English rapidly, but studied Latin and arithmetic with the teacher, after hours. He became passionately fond of books, reading their own little store with avidity. The mother, who could not even write, viewed with alarm this intellectual development, feeling that her children, if they became learned, would go away from home – possibly from Germany. Poor, ignorant heart! She cooked and sewed, and prevented her daughters from learning French or drawing; but her weak hand could not stay the power of a mind like William's, bent on acquiring knowledge.

Caroline, the eighth child, born in 1750, twelve years younger than William, looked upon this brother as a marvel; and shy, plain, and silent herself, watched the boy with pride, who, perchance, would be somebody by and by. Alexander, a little older than Caroline, was skilled on the violoncello, and both the boys became members of the Hanover foot guards.

Years later, Caroline gave this picture of that early life: "My brothers were often introduced as solo performers and assistants in the orchestra of the court, and I remember that I was frequently prevented from going to sleep by the lively criticism on music, on coming from a concert; or by conversations on philosophical subjects, which lasted frequently till morning, in which my father was a lively partaker and assistant of my brother William, by contriving self-made instruments...

"Often I would keep myself awake that I might listen to their animating remarks, for it made *me so happy to see them so happy*. But generally their conversation would branch out on philosophical subjects, when my brother William and my father often argued with such warmth that my mother's interference became necessary; when the names Leibnitz, Newton, and Euler sounded rather too loud for the repose of her little ones, who ought to be in school by seven in the morning. But it seems that on the brothers retiring to their own room, where they shared the same bed, my brother William had still a great deal to say; and frequently it happened that when he stopped for an assent or reply, he found his hearer was gone to sleep, and I suppose it was not till then that he bethought himself to do the same.

"The recollection of these happy scenes confirms me in the belief, that had my brother William not then been interrupted in his philosophical pursuits, we should have had much earlier proofs of his inventive genius. My father was a great admirer of astronomy, and had some knowledge of that science; for I remember his taking me, on a clear frosty night, into the street, to make me acquainted with several of the most beautiful constellations, after we had been gazing at a comet which was then visible. And I well remember with what delight he used to assist my brother William in his various contrivances in the pursuit of his philosophical studies, among which was a neatly turned four-inch globe, upon which the equator and ecliptic were engraved by my brother."

When William was seventeen, the guards went to England for a year, and on their return home he brought one precious memento of the country, Locke "On the Human Understanding." Such a boy

would not remain in the foot guards forever. He was delicate in health, so that his parents removed him from the army.

At nineteen, he determined to try his fortune in England. He said good-by to the culture-loving and warm-hearted father, to the poor mother who knew "no other wants than good linen and clothing," and started out to make his way in the world. For three years nothing is known of him, save that he passed through many hardships. He played in military bands whenever and wherever he could find a situation, or at concerts, and led probably a cramped and obscure life.

There was little prospect then that he would become, as Prof. Edward S. Holden says in his admirable life, "the greatest of practical astronomers, and one of the world's most profound philosophers." What the poor German youth thought and felt in those years of trial, we do not know. He had one resource in his loneliness, the reading of useful books.

After about three years, a fortuitous circumstance occurred. It proved "fortuitous" only because young Herschel had studied music faithfully, and had made himself ready to fill a fine position, if, poor and without influence, such a position could be obtained.

As Dr. Miller, a noted organist, "was dining at Pontefract with the officers of the Durham militia, one of them, knowing his love of music, told him they had a young German in their band, as a performer on the oboe, who was also an excellent performer on the violin. The officer added that if Miller would come into another room, this German should entertain him with a solo. The invitation was gladly accepted, and Miller heard a solo of Giardini's executed in a manner that surprised him.

"He afterwards took an opportunity of having some private conversation with the young musician, and asked him whether he had engaged himself for any long period to the Durham militia. The answer was, 'Only from month to month.'

"'Leave them, then,' said the organist, 'and come and live with me. I am a single man, and think we shall be happy together; and doubtless your merit will soon entitle you to a more eligible situation.'

"The offer was accepted as frankly as it was made, and the reader may imagine with what satisfaction Dr. Miller must have remembered this act of generous feeling, when he heard that this young German was Herschel, the astronomer. 'My humble mansion,' says Miller, 'consisted at that time but of two rooms. However, poor as I was, my cottage contained a library of well chosen books.'

"He took an early opportunity of introducing his new friend at Mr. Cropley's concerts. The first violin was resigned to him, 'and never,' says the organist, 'had I heard the concertos of Corelli, Geminiani, and Avison, or the overtures of Handel, performed more chastely, or more according to the original intention of the composers, than by Mr. Herschel.'

"I soon lost my companion; his fame was presently spread abroad; he had the offer of pupils, and was solicited to lead the public concerts both at Wakefield and Halifax. A new organ for the parish church of Halifax was built about this time, and Herschel was one of the seven candidates for the organist's place. They drew lots how they were to perform in succession. Herschel drew the third; the second fell to Dr. Wainwright, of Manchester, whose finger was so rapid that old Snetzler, the organ-builder, ran about the church exclaiming, "*He run over te keys like one cat; he will not give my piphes room for to shpeak.*"

"During Mr. Wainwright's performance,' says Miller, 'I was standing in the middle aisle with Herschel. "What chance have you," said I, "to follow this man?" He replied, "I don't know, I am sure fingers will not do." On which he ascended the organ loft, and produced from the organ so uncommon a fulness, such a volume of slow, solemn harmony, that I could by no means account for the effect. After this short *extempore* effusion, he finished with the Old Hundredth psalm-tune, which he played better than his opponent.

"Ay, ay," cried old Snetzler, "*tish is very goot, very goot inteet. I will hef tish man, for he gives my piphes room for to shpeak.*" Having afterwards asked Mr. Herschel by what means, in the beginning of his performance, he produced so uncommon an effect, he replied, "I told you fingers would not do!" and, producing two pieces of lead from his waistcoat pocket, "One of these," said he,

"I placed on the lowest key of the organ, and the other upon the octave above; thus, by accommodating the harmony, I produced the effect of four hands, instead of two.""

Herschel was the successful candidate among the seven. He was now twenty-seven years old. Only once do we learn of his going home to Germany, and that in the year previous. Of this visit, Caroline, now grown to fourteen, says, "Of the joys and pleasures which all felt at this long-wished-for meeting with my, let me say my *dearest* brother, but a small portion could fall to my share; for with my constant attendance at church and school, besides the time I was employed in doing the drudgery of the scullery, it was but seldom I could make one in the group when the family were assembled together.

"In the first week, some of the orchestra were invited to a concert, at which some of my brother William's compositions – overtures, etc. – and some of my eldest brother, Jacob's, were performed, to the great delight of my dear father, who hoped and expected that they would be turned to some profit by publishing them, but there was no printer who bid high enough."

After a year at Halifax, Herschel obtained a position as organist at the Octagon Chapel in Bath, a fashionable city of England. This was another and higher step on the road to fame. He now gave nearly forty lessons a week to pupils. He composed music, and wrote anthems, chants, and psalm-tunes for the cathedral choir where he played. He became so popular from his real ability, coupled with pleasing manners, that he was occupied in teaching from fourteen to sixteen hours daily.

But he did more than this. As his hopes brightened, he determined to devote every minute to the pursuit of knowledge, in which he found his greatest happiness. He studied Greek and Italian. He would *unbend his mind*, after he retired, with Maclaurin's "Fluxions," or Robert Smith's "Complete System of Optics," and Lalande's Astronomy.

What if he had devoted this time to ease or amusement! Would he have become learned or distinguished? Every young man and woman is obliged to decide the matter for himself and herself. We cannot idle away life and be great.

In 1767, the fond father, Isaac, died of paralysis. Caroline, who loved him tenderly, was desolate. He had taught her the violin when the prosaic mother "was either in good humor, or out of the way." It is quite possible that music, like inventions, did not bring an adequate support for ten children, and that the practical mother wished her daughter to learn something whereby she could earn a living. She thereupon sent her two or three months to a seamstress to be taught to make household linen. After a time a delightful proposition came from the organist at Bath. He would take her to England, and see if she "could not become a useful singer for his winter concerts and oratorios." If she did not succeed, after two years, he would carry her back to Germany.

In 1772, William came to Hanover and took his sister to Bath, at 7 New Kings Street. She was now twenty-two; an untutored girl, with a bright, eager mind, and a heart that went out to her brother in the most rapt devotion. History does not show a more complete, single-hearted, subservient affection, nor a sadder picture of a woman's sorrow in later years, in consequence of it.

At once Caroline began her work of voice culture, lessons in arithmetic, English, and in keeping accounts, from her brother, and in managing the house. Alexander, now in England, boarded with William, and he and Caroline occupied the attic. The first three winter months were lonely, as she saw little of William.

"The time," she says, "when I could hope to receive a little more of my brother's instruction and attention was now drawing near; for after Easter, Bath becomes very empty, only a few of his scholars, whose families were residents in the neighborhood, remaining. But I was greatly disappointed, for, in consequence of the harassing and fatiguing life he had led during the winter months, he used to retire to bed with a basin of milk or glass of water, and Smith's Harmonics and Optics, Ferguson's Astronomy, etc., and so went to sleep buried under his favorite authors; and his first thoughts on rising were how to obtain the instruments for viewing those objects himself of which he had been reading.

"There being in one of the shops a two-and-a-half-foot Gregorian telescope to be let, it was for some time taken in requisition, and served not only for viewing the heavens, but for making experiments on its construction... It soon appeared that my brother was not contented with knowing what former observers had seen, for he began to contrive a telescope eighteen or twenty feet long... I was much hindered in my musical practice by my help being continually wanted in the execution of the various contrivances, and I had to amuse myself with making the tube of pasteboard for the glasses, which were to arrive from London, for at that time no optician had settled at Bath. But when all was finished, no one besides my brother could get a glimpse of Jupiter or Saturn, for the great length of the tube would not allow it to be kept in a straight line. This difficulty, however, was soon removed by substituting tin tubes."

Herschel had attempted to buy a telescope, but found the price far beyond his means. But he was not discouraged. Caroline soon saw "almost every room turned into a work-shop. A cabinet-maker making a tube and stands of all descriptions in a handsomely furnished drawing-room;" this could be so occupied when the music scholars had left Bath in their vacation; "Alex putting up a huge turning machine in a bedroom, for turning patterns, grinding glasses, and turning eye-pieces, etc."

The longed-for time to see more of her brother never came to Caroline, except as she finally grew into his life-work, and became his second self.

He had one unalterable purpose, the study of the construction of the heavens. Nothing ever drew him from it. Nothing ever could draw him. And herein lay one of the elements of his great power. As an English writer has well said: "So gentle and patient a follower of science under difficulties scarcely occurs in the whole circle of biography." Yes, he was "gentle and patient," but with an untiring and never ending perseverance. Too poor to buy telescopes, he made them. With no time to read books during the day, he took the hours from sleep. With little opportunity for education, he educated himself.

In 1774, the music teacher made for himself a five-and-one-half-foot Gregorian telescope; and a year later, a Newtonian, with a four-and-a-half-inch aperture, which magnified two hundred and twenty-two times. The making of these instruments showed great mechanical skill and accurate knowledge. He began now to study the heavens in earnest, but the teaching must go on to provide daily bread. He directed an orchestra of nearly one hundred pieces, and Caroline copied the scores and vocal parts. So absorbed was he in his astronomical work, however, that at the theatre, between the acts, he would run from the harpsichord to look at the stars. This boyish eagerness and naturalness he kept through life.

He soon made a seven-foot reflector, then a ten-foot reflector. The mirrors for these telescopes were all made by hand, machines for the purpose not being invented till ten or more years later. Alexander, with his mechanical skill, assisted, and Caroline was always busy at the work. She says, "My time was taken up with copying music and practising, besides attendance on my brother when polishing; since, by way of keeping him alive, I was constantly obliged to feed him, by putting his victuals by bits into his mouth. This was once the case, when, in order to finish a seven-foot mirror, he had not taken his hands from it for sixteen hours together. In general he was never unemployed at meals, but was always at those times contriving or making drawings of whatever came in his mind. Generally I was obliged to read to him while he was at the turning-lathe, or polishing mirrors, 'Don Quixote,' 'Arabian Nights' Entertainment,' the novels of Sterne, Fielding, etc.; serving tea and supper without interrupting the work with which he was engaged."...

So busy that he could not find time to eat or sleep! Rare devotion of a rare mind! He now began to study every star of the first, second, third, and fourth magnitudes in the sky. He carefully observed the moon, and measured the height of about one hundred of her mountains. Her extinct volcanoes, and her unpeopled solitudes, without clouds or air, were an impressive study.

He was now forty years old, – not young to begin the study of a new and illimitable science, but not too old, for one is never too old to begin a great or a noble work.

Through Dr. William Watson, Fellow of the Royal Society, who happened – if anything ever *happens* in this world – to see Herschel at his telescope, he became a member of the Philosophical Society of Bath, and soon in 1780 sent two papers to the Royal Society, the one on the periodical star in *Collo Ceti*, and the other on the mountains of the moon, which were read by Dr. William Watson, Jr.

When he was forty-three, he says, "I began to construct a thirty-foot aërial reflector, and, having made a stand for it, I cast the mirror thirty-six inches in diameter. This was cracked in cooling. I cast it a second time, and the furnace I had built in my house broke." But he persevered. This same year, 1781, after he had lived in Bath nine years, on the night of Tuesday, March 13, having removed to a larger house, 19 New King Street, he says, "In examining the small stars in the neighborhood of *H. Geminorum* I perceived one that appeared visibly larger than the rest; being struck with its uncommon appearance, I compared it to *H. Geminorum* and the small star in the quarter between Auriga and Gemini, and, finding it so much larger than either of them, I suspected it to be a comet."

The orbit of this "comet" was computed and its distance from the sun found to be eighteen hundred million miles! The world soon awoke to the fact that a new planet had been found, the greatest astronomical discovery since Galileo invented the telescope, and the unknown musician at Bath had become famous! So little was Herschel known at this time, that one journal called him Mersthel, another Herthel, and still another Hermstel.

In December of the same year, 1781, Herschel was elected a Fellow of the Royal Society and received the Copley gold medal. He was no longer the poor German youth playing the oboe among the guards; he was the renowned discoverer. He called the planet Georgium Sidus, in honor of his sovereign, George III., but it was decided later to call it Uranus, from Urania the muse of astronomy.

Herschel went eagerly on with his work. Fame did not change his simple nature. The truly great are never ostentatious. He erected in his garden a stand for his twenty-foot telescope, and perfected his mirrors. "Though at times," says Caroline, "much harassed with business, the mirror for the thirty-foot reflector was never out of his mind, and if a minute could but be spared in going from one scholar to another, or giving one the slip, he called at home to see how the men went on with the furnace, which was built in a room below, even with the garden."

The next year, 1782, Herschel went to London, and met with a gracious reception from George III. He wrote back to his devoted sister: "Dear Lina: All my papers are printing, with the postscript and all, and are allowed to be very valuable. You see, Lina, I tell you all these things. You know vanity is not my foible, therefore I need not fear your censure. Farewell.

*"I am your affectionate brother,
"Wm. Herschel."*

Again he wrote, —

"I pass my time between Greenwich and London, agreeably enough, but am rather at a loss for work that I like. Company is not always pleasing, and I would much rather be polishing a speculum... I am introduced to the best company. To-morrow I dine at Lord Palmerston's, next day with Sir Joseph Banks, etc., etc. Among opticians and astronomers nothing now is talked of but *what they call* my great discoveries. Alas! this shows how far they are behind, when such trifles as I have seen and done are called *great*. Let me but get at it again! I will make such telescopes, and see such things – that is, I will endeavor to do so."

And this great ambition nerved him for action, continued and laborious, as long as he lived. He was never satisfied; always achieving. Little can be expected from those who are easily satisfied.

George III. wisely appointed Herschel Royal Astronomer, though with the too small salary of one thousand dollars yearly. He came back to Bath only to perform the last musical duty on Whit Sunday, 1782, the anthem for the day being his own composition, and to say good-by to his pupils.

He moved to Datchet in 1782, and set up his twenty-foot telescope. In 1783 he had made three reviews of the heavens. In 1784 he made a fourth review with his twenty-foot telescope. Caroline says:

"My brother began his sweeps when the instrument was yet in a very unfinished state, and my feelings were not very comfortable when every moment I was alarmed by a crash or a fall, knowing him to be elevated fifteen feet or more on a temporary crossbeam, instead of a safe gallery. The ladders had not even their braces at the bottom; and one night, in a very high wind, he had hardly touched the ground before the whole apparatus came down... I could give a pretty long list of accidents which were near proving fatal to my brother as well as myself."

A gentleman who visited him at Datchet wrote: "The thermometer in the garden stood at 13° Fahrenheit; but in spite of this, Herschel observes the whole night through, except that he stops every three or four hours and goes in the room for a few moments. For some years Herschel has observed the heavens every hour when the weather is clear, and this always in the open air, because he says that the telescope only performs well when it is at the same temperature as the air. He protects himself against the weather by putting on more clothing. He has an excellent constitution, and thinks about nothing else in the world but the celestial bodies."

But, occupied as Herschel was about "celestial bodies," he yet found time to think about earthly things, for we find him at forty-five, May 8, 1783, marrying Mary, the wealthy widow of John Pitt, Esq., a lady of much intelligence and amiability.

The sad feature of the new relationship was the misery it brought to Caroline. Her whole life had centred in William. For eleven years she had devoted every moment, every wish, every thought to him. She had watched all night among the stars with him, month after month, and year after year, in cold and in heat, and superintended his home by day. His every desire was her law. She loved no other, and he was her all. Perhaps she ought to have known that another might come into his life, but she trusted blindly, and did not question the future.

When the wife came into the home, Caroline went out of it forever. For more than twenty years she lived in lodgings, always "cheerless and solitary," her only happiness found in coming day by day to help her brother in his great work. Sometimes, when the wife was absent, Caroline came back for a few days and lived over the old unalloyed life, and then went back to her lonely lodgings.

For ten years following this marriage, she probably told her heart-aches in her journal; but before her death she destroyed the record of these years, that the feelings of those who were alive might not be pained. In later days she became more reconciled to Lady Herschel, as "a dear sister, for as such I now know you," and idolized their only son, the renowned Sir John Herschel, born nine years after their marriage.

In 1785, Herschel began to construct his great forty-foot telescope, and the next year removed to Slough, not far from Windsor. "In the whole of the apparatus," he said, "none but common workmen were employed, for I made drawings of every part of it, by which it was easy to execute the work, as I constantly inspected and directed every person's labor; though sometimes there were not less than forty different workmen employed at the same time. While the stand of the telescope was preparing, I also began the construction of the great mirror, of which I inspected the casting, grinding, and polishing; and the work was in this manner carried on with no other interruption than that occasioned by the removal of all the apparatus and materials from where I then lived, to my present situation at Slough." He had his first view through the telescope February 19, 1787. George III. gave twenty thousand dollars for the building of this instrument, and one thousand dollars yearly for its maintenance.

A half-century afterwards, the woodwork having become decayed, it was taken down, the great tube laid horizontally, and, after Sir John Herschel and his family had passed through it, a poem written by Sir John having been read, it was sealed January 1, 1840, and placed on piers.

With this great telescope, Herschel discovered two satellites of Saturn, Mimas and Enceladus; one on August 27, 1789, and the other on September 17 of the same year. Two years before this, January 11, 1787, he discovered two satellites of Uranus, Oberon and Titania. Sixty years afterwards, Mr. Lassell, of England, discovered the remaining two satellites of Uranus, called Ariel and Umbriel.

From this time his work went forward grandly. He had already completed more than two hundred seven-foot, one hundred and fifty ten-foot, and eighty twenty-foot mirrors. For many of the telescopes sent abroad he made no stands, but provided the drawings. He wrote much about Saturn and its rings, and showed that its most distant satellite, Japetus, turns once on its axis in each revolution about its primary, as our moon does about the earth.

He studied carefully the nature of the sun, its probable gaseous surface, and its spots, and was the first to suspect their periodic character. What would Herschel have said to the wonderful photographic representations of these spots given by Professor Langley, in his *New Astronomy*; spots which are one billion square miles in size; more than five times the surface of the land and water on the earth? He saw, as astronomers to-day see, that heat cannot be produced without expenditure of force; and that the sun is probably cooling, even though scarcely perceptibly for ages to come. He saw what science now generally concedes, the rise and fall of the solar system; its gradual fitness for the coming of man, through almost countless centuries; and its final unfitness, when his generations shall have gone forever.

He wrote much about the Milky Way, believing at first that it could be completely resolved into stars, about eighteen millions of them; but later he changed his theory, having found so much nebulous matter – in a state of condensation as though new worlds were forming, possibly to be the homes of some new race, or of man in the ages to come.

His study of the variable stars attracted wide attention. He found that the star *Mira Ceti* was for several months invisible to the naked eye; then it grew brighter and brighter, and finally disappeared for months, as before. He saw that other stars are periodic, and came to the conclusion that this is occasioned by the rotation of the star upon its axis, by which different parts of its surface are presented to us periodically.

He made a catalogue of double stars, and found by laborious calculations that such stars have a common centre of gravity; that one sun revolves about another. He found that our solar system has a motion of its own; a grand orbit round some as yet unknown centre, and that other systems have a like motion.

What this centre may be, whether a great sun like Sirius, one hundred times larger than ours, with unknown powers and unknown uses, is of course only conjecture.

Herschel gave much attention to nebulae, discovering and describing twenty-five hundred new nebulae and clusters. He gave his life to the study of the construction of the heavens. Concerning his statement of the general construction, Professor Holden, himself a brilliant astronomer, says: "It is the groundwork upon which we have still to build... As a scientific conception it is perhaps the grandest that has ever entered into the human mind. As a study of the height to which the efforts of one man may go, it is almost without a parallel... As a practical astronomer he remains without an equal. In profound philosophy he has few superiors. By a kindly chance he can be claimed as the citizen of no one country. In very truth his is one of the few names which belong to the whole world."

The distinguished man, though unassuming and gentle in manner, must have had a realizing sense of the greatness of his work, for he said, "I have looked further into space than ever human being did before me. I have observed stars of which the light takes *two millions* of years to travel to this globe."

He gave much study to light and heat. So boundless was his knowledge believed to be, that a farmer called one day to ask the proper time for cutting his grass.

"Look at that field," said the scientist, "and when I tell you it is mine, I think you will not need another proof to convince you that I am no more weatherwise than yourself or the rest of my neighbors."

He worked earnestly till he was seventy-six, always depending upon his faithful and inseparable Caroline for aid in his labors. He made a telescope for her, with which she swept the heavens for comets, finding eight, five of which she discovered for the first time.

At seventy-six his health began to fail. He had worked incessantly from his struggling boyhood, but brain work does not wear us out; care and anxiety bring the marks of age upon us. He now took little journeys away from Slough for change of scene and air, while Caroline stayed at home to copy his papers for the Royal Society, and to arrange his manuscripts. In 1816, he was made a knight of the Royal Hanoverian Guelphic Order, by the Prince Regent, and in 1821 was the first president of the Royal Astronomical Society, his son being its first foreign secretary.

In February, 1818, Caroline spent twelve precious days with her brother, "not in idleness," she says, "but in sorrow and sadness. He is not only unwell, but low in spirits." Later he went to Bath with Lady Herschel. "The last moments before he stepped into the carriage," says the loving Caroline, "were spent in walking with me through his library and workrooms, pointing with anxious looks to every shelf and drawer, desiring me to examine all and to make memorandums of them as well as I could. He was hardly able to support himself, and his spirits were so low, that I found difficulty in commanding my voice so far as to give him the assurance he should find on his return that my time had not been misspent.

"When I was left alone I found that I had no easy task to perform, for there were packets of writings to be examined which had not been looked at for the last forty years. But I did not pass a single day without working in the library as long as I could read a letter without candle-light, and taking with me papers to copy, etc., which employed me for the *best part of the night*, and thus I was enabled to give my brother a clear account of what had been done at his return."

On the 4th of July, 1819, Herschel sent a note to his dear co-worker. "Lina, – There is a great comet. I want you to assist me. Come to dine and spend the day here. If you can come soon after one o'clock we shall have time to prepare maps and telescopes. I saw its situation last night, – it has a long tail."

Caroline wrote on this small slip of yellow paper: "I keep this as a relic! Every line *now* traced by the hand of my dear brother becomes a treasure to me."

Every day hereafter she spent the forenoon with Sir William. On the 15th of August she went as usual and found that he was confined to his room. "I flew there immediately," she says. "As soon as he saw me, I was sent to the library to fetch one of his last papers and a plate of the forty-foot telescope. But for the universe I could not have looked twice at what I had snatched from the shelf, and when he faintly asked if the breaking up of the Milky Way was in it, I said 'Yes!' and he looked content. I cannot help remembering this circumstance, it was the last time I was sent to the library on such an occasion. That the anxious care for his papers and workroom never ended but with his life was proved by his frequent whispered inquiries if they were locked and the key safe, of which I took care to assure him that they were, and the key in Lady Herschel's hands.

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